Spiorad na Mara Offshore Wind Farm

Offshore Project

Environmental Impact Assessment Report

Annex 15.1.2: Archaeological Assessment of Geophysical and Hydrographic Data, Volume 2c

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1 INTRODUCTION

1.1 OVERVIEW

1.1.1.1 This annex of the Environmental Impact Assessment Report (EIAR) presents archaeological assessment of geophysical and hydrographic survey data of the proposed Spiorad na Mara Offshore Wind Farm (hereafter referred to as 'the Offshore Project') with respect to Marine Archaeology and Cultural Heritage and this assessment has been undertaken by MSDS Marine Limited (MSDS Marine). This annex accompanies **Appendix 15.1: Marine Archaeology Desk Based Assessment, Volume 2c** and **Chapter 12: Marine Archaeology and Cultural Heritage, Volume 2a** of the EIAR.

1.1.1.2 This annex should be read in conjunction with the project description provided in **Chapter 3: Project Description, Volume 1a**.

1.1.1.3 This report is a point in time document that covers the whole of the original scope of the Offshore Project and as such does not reflect all changes to design and Study Areas as the Offshore Project progresses.

PROJECT BACKGROUND

1.1.1.4 Spiorad na Mara Limited (hereafter referred to as 'the Applicant') is proposing to develop the Project. The Project is an offshore wind farm (OWF) that will consist of up to 60 fixed-bottom wind turbine generators (WTGs).

1.1.1.5 The Project will include both offshore and onshore infrastructure. This EIAR supports the application for the offshore components of the Project as outlined in **Chapter 1: Introduction, Volume 1a**. The offshore components of the Project (the Offshore Project) includes all infrastructure and activities located seaward of Mean High Water Springs (MHWS) within the Array Area and Offshore Cable Area of Search (OCAS) (**Figure 1.2: Offshore Project Location, Volume 1c**). Further detailed information is provided in **Chapter 3, Volume 1a**.

1.1.1.6 The Offshore Project is situated off the northwest coast of Isle of Lewis/*Eilean Leòdhais* and the Array Area is located approximately 5-13 km offshore and is approximately 161 km^2 in size. It will comprise WTGs, foundations, Offshore Cables, Offshore Substation Platform (if required), and Landfall. The Array Area combined with the OCAS is defined as the Offshore Project Boundary. The water depths across the Array Area range from 37 m-67 m with the southwest corner of the Array Area reaching 72 m. The proposed WTGs and fixed foundations will be located within a Turbine Area of approximately 140 km^2, within the Array Area.

1.2 PURPOSE OF THIS ANNEX

1.2.1.1 This annex describes the following:

- Existing infrastructure (Section 2);
- Methodology (Section 3);
- Results of surface geophysical anomalies (Section 4);
- Result of magnetic anomalies (Section 5);
- United Kingdom Hydrographic Office (UKHO) records (Section 6)
- Canmore records (Section 7);
- Historic environment records (Section 8);
- Palaeolandscape assessment (Section 9);
- Mitigation (Section 10);
- Recommendations for future work (Section 11).

1.3 THE SURVEY

1.3.1.1 The survey was conducted by Ondine Limited (Ondine), on behalf of Aratellus Subsea Solutions PTE Limited (Aratellus) between 15 May 2023 and 6 December 2023. The mobilised sensors consisted of Sidescan Sonar (SSS), Multibeam Bathymetry (MBES), Magnetometer, Parametric Sub-bottom Profiler (SBP), and Ultra High Resolution Seismics (UHRS).

1.3.1.2 The assessment is being undertaken to inform the EIAR. This document forms the archaeological assessment of the geophysical and hydrographic survey data, and outlines the specification of the data, the method of archaeological assessment, the presentation of the results, and recommendations for mitigation strategies.

1.4 ARCHAEOLOGICAL REVIEW OF GEOPHYSICAL AND HYDROGRAPHIC DATA

1.4.1.1 The principal aim of the archaeological review of geophysical and hydrographic data is to establish the presence of material of potential archaeological significance on the seabed, and the potential for submerged prehistoric remains laid down during different climatic and environmental conditions in the past. The identification of material and geological horizons allows for strategies to be recommended to mitigate against any negative effects that may be caused by the development process.

1.4.1.2 The objectives of the archaeological interpretation can be summarised as follows:

- To establish the presence of anthropogenic material of archaeological potential;
- To interpret the identified anomalies as to their potential to be of archaeological significance;
- To recommend mitigation strategies for the anomalies appropriate to their archaeological potential;
- To establish the palaeolandscape potential;

- To recommend mitigation strategies in relation to the palaeolandscape and palaeoenvironment;
- To recommend further works that may be required and their specifications.

2 EXISTING INFRASTRUCTURE

2.1.1.1 Existing third-party infrastructure within the Array survey area was identified through interrogation of data sets from Kingfisher Information Service – Offshore Renewable & Cable Awareness (KIS-ORCA, 2025) and Oil and Gas data from the United Kingdom Continental Shelf (UKCS) supplied by the North Sea Transition Authority (NSTA, 2025). In addition, magnetometer data were reviewed to identify linear features that may represent cables and pipes.

2.1.1.2 No existing, recorded, cables were identified within the Array survey area or the extents of the geophysical and hydrographic data. No recorded pipelines, wells, bottom holes, or wells paths were identified within Array Area in the extents of the geophysical and hydrographic data.

2.1.1.3 No evidence of cables, pipelines, or infrastructure was identified with the geophysical and hydrographic data.

3 METHODOLOGY

3.1 DATA COLLECTION

3.1.1.1 The survey was conducted by Ondine, on behalf of Aratellus between 15 May 2023 and 6 December 2023. The mobilised sensors consisted of SSS, MBES, Magnetometer, Parametric SBP, and UHRS. The survey was undertaken by the *Ondine Jule* between the 30 May 2023 and the 30 August 2023, and the *Glomar Supporter* between 15 May 2023 and the 19 July 2023. The *Ondine Jule* was remobilised on the 16 November 2023 to undertake MBES infill and was demobilised on the 6 December 2023. The SSS, Magnetometer (piggy backed to the SSS), and UHRS were towed behind the vessel, the MBES and SBP were mounted to the vessels.

3.1.1.2 Survey operations were undertaken within a pre-defined boundary of Array Area. The SSS, Magnetometer, MBES and SBP survey was planned with a line spacing of 100 m for the main lines, and 1,500 m for the cross lines. The line spacing ensured 100% coverage of MBES data (with a minimum of 10% overlap) and 200% coverage of SSS. The UHRS survey was planned with a line spacing of 500 m for the main lines, and 1,500 m for the cross lines. In addition, SBP, Sparker, and Magnetometer data were collected along each of the survey lines. The Magnetometer survey navigation tracklines are presented in **Plate 3-1,** the SSS coverage in **Plate 3-2**, the MBES coverage in **Plate 3-3**, the UHRS survey navigation tracklines in **Plate 3-4**, and the SBP survey navigation tracklines in **Plate 3-5**. The equipment specification for the surveys is shown in **Table 3-1.**

Table 3-1 Geophysical and hydrographic sensor specifications

Sensor	Manufacturer	Model	Frequency
Ondine Jule			
Sidescan Sonar	Edgetech	4205	230/540 kHz
Multibeam	R2Sonic	2024	170-450 kHz
Magnetometer	Geometrics	G-882	>10 m altitude
Parametric SBP	Innomar	SES-2000 Medium	4-15 kHz
UHRS	Applied Acoustics	Dura-Spark 400	0.3 to 1.2 kHz
Glomar Supporter			
Sidescan Sonar	Edgetech	4205	230/540 kHz
Multibeam	R2Sonic	2026 (dual head)	170-450 kHz
Magnetometer	Geometrics	G-882	>10 m altitude
Parametric SBP	Innomar	SES-2000 Medium	4-15 kHz
UHRS	Applied Acoustics	Dura-Spark 400	0.3 to 1.2 kHz

3.1.1.3 The data were collected to a specification appropriate to achieve the following interpretation requirements:

- Sidescan Sonar: ensonification of anomalies > 0.5 m;
- Multibeam Bathymetry: ensonification of anomalies > 1.0 m;
- Magnetometer (TVG): 5.0 nT threshold for anomaly picking (noting that whilst the specification was appropriate, geological factors meant this was not possible);
- Parametric SBP: penetration to bedrock was largely achieved;
- UHRS: penetration to bedrock was largely achieved.

3.2 POSITIONING

3.2.1.1 All data were collected with reference to the European Terrestrial Reference System 1989 (ETRS89) datum and a customer Transverse Mercator projection (**Table 3-2**).

Table 3-2 Geodetic parameters

Projection Parameters	
Grid Projection	TM 6NW
Central Meridian Zone 29 (CM)	6°W
Origin Latitude (False Lat.)	0°N
False Easting (FE)	1,500,000 m
False Northing (FN)	0.0 m
Scale Factor on CM	1.0
Units	Meter
Global Navigation Satellite System (GNSS) Geodetic Parameters	
Datum	ETRS89
Ellipsoid	GR80
Semi-Major Axis (a)	6,378,137.0 m
Inverse Flattening (1/f)	298.257222101

3.2.1.2 Positions within this report are presented with reference to the World Geodetic System 1984 (WGS84) datum and Universal Transverse Mercator (UTM) Zone 29 North projection (WGS84 Z29N) (EPSG: 32629).

3.2.1.3 All vertical depths are relative to Mean Sea Level (MSL) and were reduced to LAT using Vertical Offshore Reference Frames (VORF) model V2.1 2008.

3.2.1.4 Towed sensors were positioned using an Ultra Short Baseline (USBL) positioning system to ensure positional accuracy throughout the survey. USBL ensures the actual position of the sensor is recorded, as opposed to when the position is estimated based upon the direction of the vessel and the amount of cable out (layback).

3.2.1.5 Although the accuracy of the USBL system is dependent on the angle, and the distance of the beacon from the transceiver, tolerances of between 0.5 m and 2.0 m can be achieved. Positional accuracy is further increased through the correlation of the SSS dataset with the MBES dataset.

3.2.1.6 Surface and sub-sea position sensors specifications are detailed in **Table 3-3.**

Table 3-3 Position sensor specifications

Sensor	**Manufacturer**	**Model**	**Frequency**
Ondine Jule			
Surface Positioning	Applanix	POS MV	Roll / pitch 0.008° Heading 0.02° Position 0.01 m
Sub-sea Positioning	Sonardyne	Mini Ranger 2	0.06% slant range
Glomar Supporter			
Surface Positioning	Applanix	POS MV	Roll / pitch 0.008° Heading 0.02° Position 0.01 m
Sub-sea Positioning	iXblue	Gaps M5	0.1% slant range

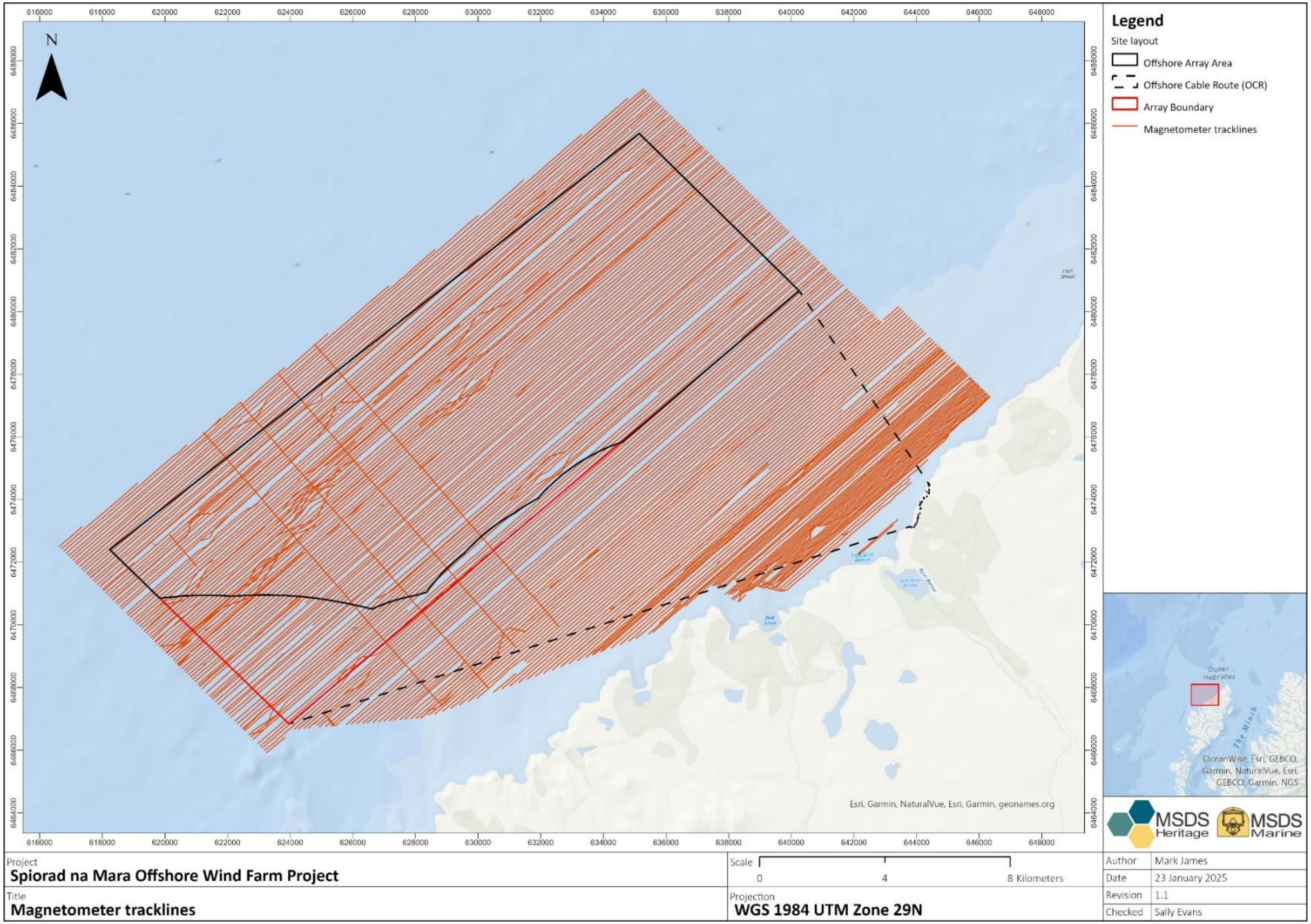

Plate 3-1 Magnetometer tracklines

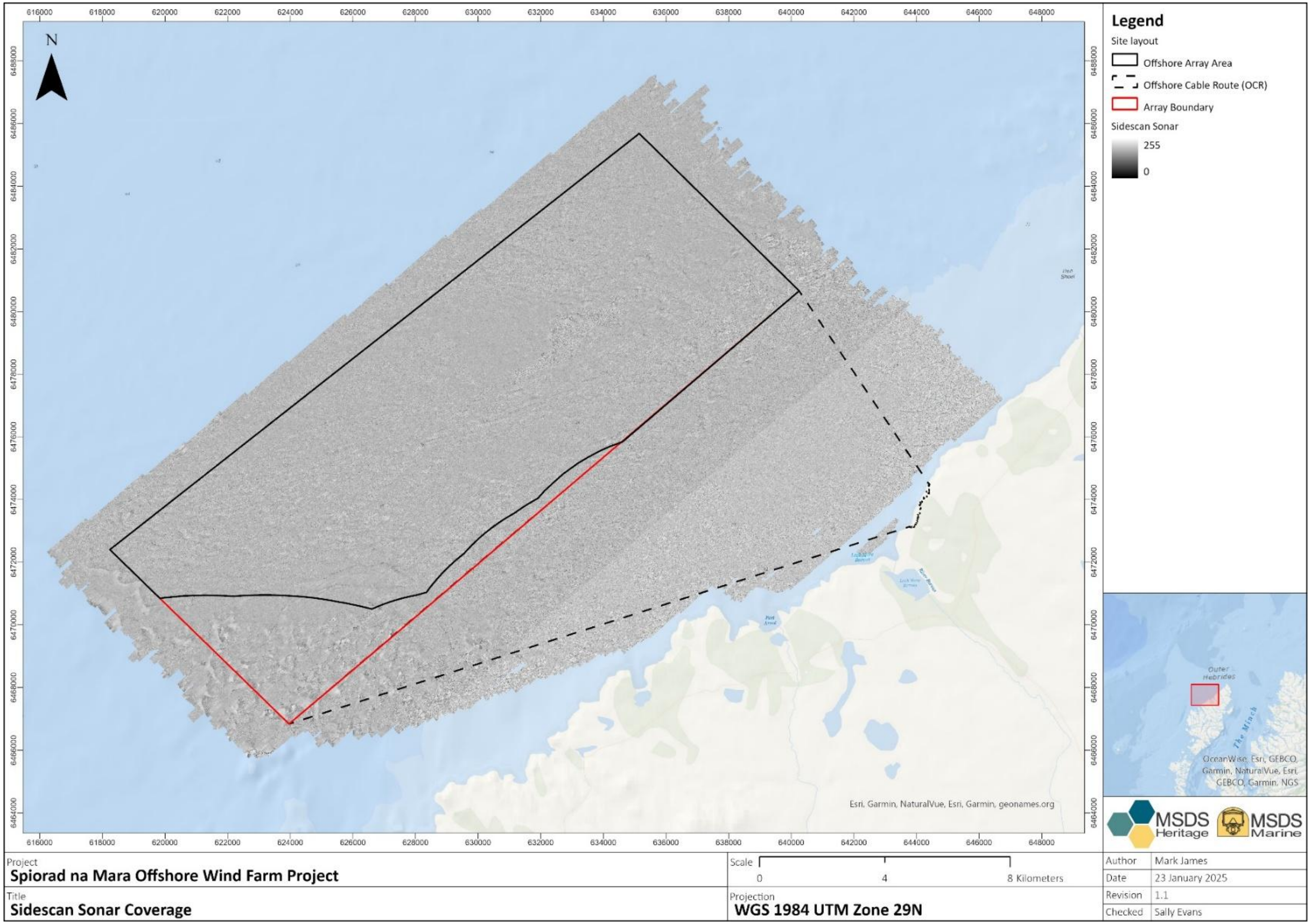

Plate 3-2 Sidescan Sonar coverage

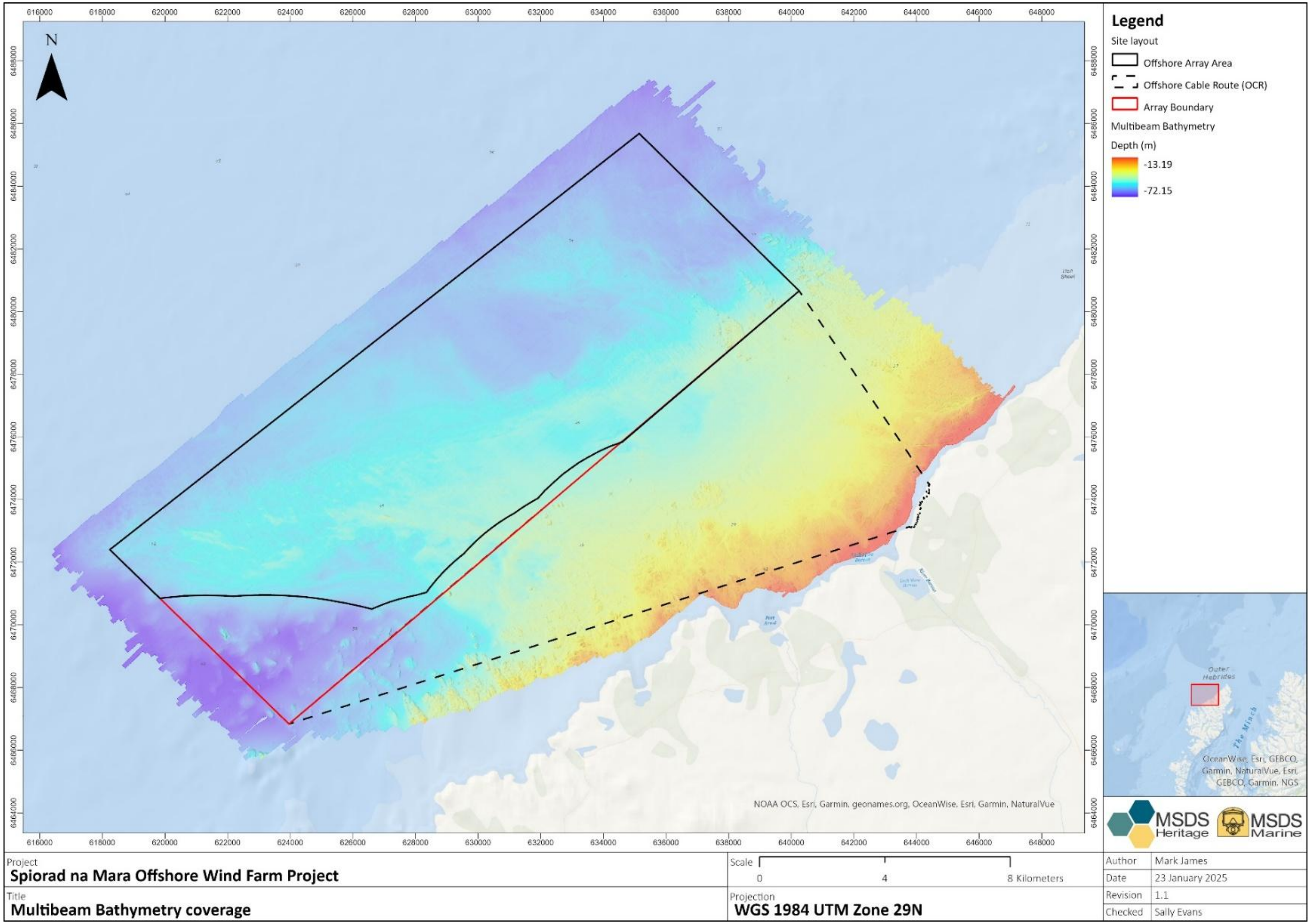

Plate 3-3 Multibeam Bathymetry coverage

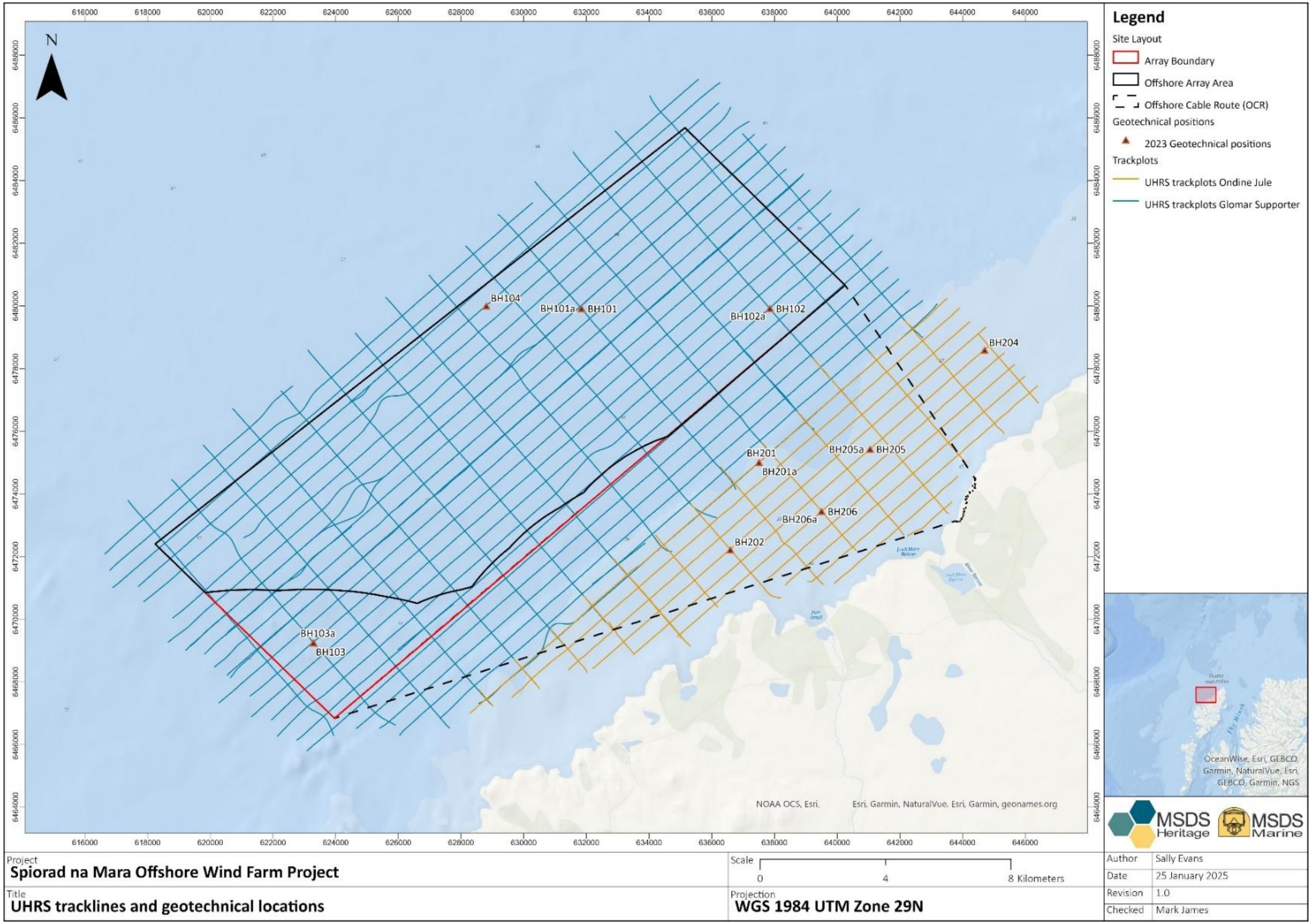

Plate 3-4 UHRS tracklines and geotechnical locations

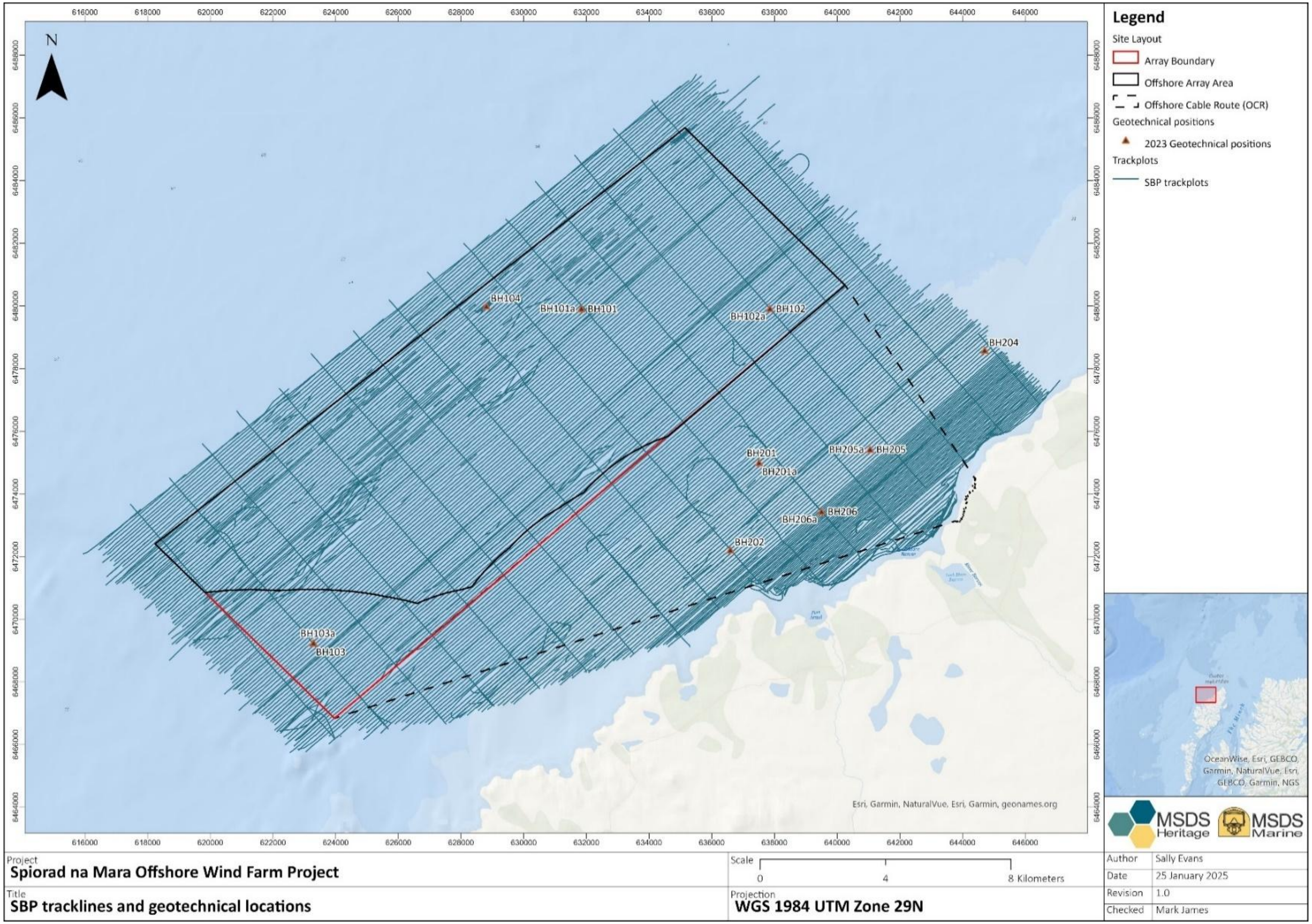

Plate 3-5 SBP tracklines and geotechnical locations

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3.3 DATA DELIVERABLES TO MSDS MARINE

3.3.1.1 MSDS Marine were provided with the survey deliverables by the Applicant, including both raw and processed data, alongside interpretations and operations reports. The primary deliverables are detailed in **Table 3-4**.

Table 3-4 Data deliverables to MSDS Marine

Sensor	Data Type	Format
Sidescan Sonar	Raw lines (low frequency (LF) and high frequency (HF))	.xtf
	Processed lines (HF)	.xtf
	Mosaic (HF) 0.5 ppm	.tif
	Contacts	.shp
Sub-bottom Profiler (both)	Raw lines	.sgy
	Processed lines	.sgy
	Isopach	.shp
	Horizons	.tif
TVG	Raw lines	.csv
	Grids	.tif
	Contacts	.csv
Multibeam Bathymetry	Raw lines	.xyz
	Grids (at 0.5 m)	.xyz
	Mosaic (at 0.5 m)	.tiff
GIS	Geodatabase	.gdb
Reports	Geophysical factual report	.pdf
	Field operations report	.pdf

3.4 DATA QUALITY AND LIMITATIONS

3.4.1 SPATIAL COVERAGE

3.4.1.1 The survey achieved full coverage of the predefined Array survey area, and almost full coverage of the OCAS survey area. Data was not collected to the shoreward extents of the OCAS, due to the depth of water and underwater hazards. Following post-survey revisions to the Array and OCAS boundaries, the coverage extends past the Array Area by >1.0 km and broadly conforms to the OCAS boundary with the exception of the nearshore area discussed. The unsurveyed areas have not been subject to archaeological assessment.

3.4.2 SIDESCAN SONAR

3.4.2.1 The SSS data covered the extents of the Offshore Project (noting the unsurveyed area in the OCAS), providing coverage of approximately 200% (excluding the nadir). The data were generally of good quality. The high frequency OCAS dataset demonstrated a notable drop off in data quality at the outer extents of the range (both port and starboard) likely due to the limitations of the system, this was largely mitigated by the line spacing allowing for 100% coverage of the unaffected data. Striations were observed in the Array Area dataset, likely as a result of snatching on the SSS cable caused by vessel motion, the striations only had a limited impact on the archaeological assessment, distorting some features.

3.4.2.2 Some small horizontal offsets were noted in places between the SSS and MBES data, although these were not significant and were within what would be considered normal tolerances. However, the positions of anomalies were taken from the MBES data where visible to ensure positional accuracy.

3.4.2.3 An assessment of seabed composition and morphological features was made based on the interpretations contained within the 2023 survey geodatabase provided by the Applicant. Seabed composition and features can affect the appearance, and interpretation, of anomalies as well as the likelihood of anomalies being obscured or buried. Seabed composition varies across Array survey area, predominantly comprising gravels with a high density of boulders. Sands are largely confined to patches within the southwest and northeast of the Array Area. The OCAS is largely characterised by outcropping bedrock, with distinct gullies, appearing to extend from the shore (**Plate 3-6**).

3.4.2.4 Prominent features such as rock outcrops with gullies can impact the ability to undertake archaeological interpretation due to obstructions to the line of sight of the sonar, in particular the SSS, the data from which is collected closer to the seabed. Typically, this is mitigated through the collection of 200% coverage SSS data, ensuring that the seabed is ensonified from 2 directions. Mitigation is further enhanced by the collection of MBES data which collected from above the seabed, thus ensonifying areas that may be obscured in the SSS data.

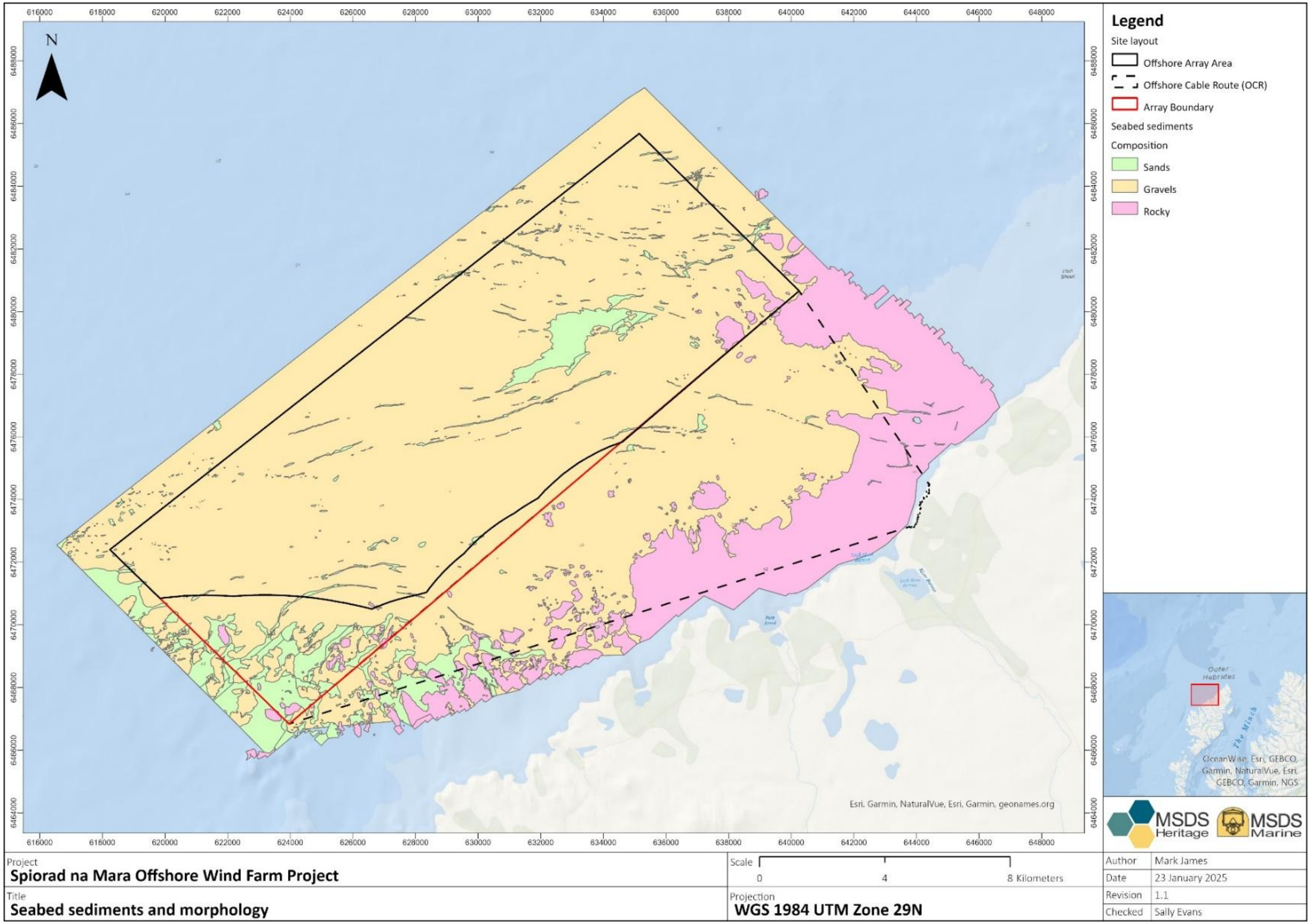

Plate 3-6 Distribution of Seabed Sediments

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3.4.3 MULTIBEAM BATHYMETRY

3.4.3.1 The MBES data covered the extents of the Offshore Project (noting the unsurveyed area in the OCAS), providing coverage of almost 100%. Small data gaps are visible in the data, largely within the Array Area. A review of the un-gridded point cloud data shows that the quality is reasonable. The data density is good, and the data is able to be gridded to 0.5 m, increasing the ability to identify smaller features. The effects of uncalibrated motion are visible along the outer edges of individual lines, as well as slight height differences between individual lines (**Plate 3-7**), whilst these errors do not create a visually pleasing dataset, their impact to archaeological assessment is limited, primarily due to the concurrent assessment of SSS data.

3.4.3.2 Features identified within the MBES data generally correlate well with those identified in the SSS data. MBES data is considered to provide the most accurate positioning due to the direct, and fixed, correlation between the sensor, the differential GNSS antennas, and the Motion Reference Unit (MRU) and is the primary source of anomaly positioning.

3.4.4 MAGNETOMETER

3.4.4.1 The Magnetometer data covered the extents of the Offshore Project (noting the unsurveyed area in the OCAS) and was collected along the pre-defined survey line plan of 100 m in most areas. The data were sampled at 10 Hz and were largely of good quality. It should be noted that the 100 m line spacing achieved is too great for the accurate positioning of magnetic anomalies at distances away from the tracklines but can indicate areas of archaeological potential or can be correlated with visible feature on the seabed that lie on the same plane. Due to the line spacing there is the potential that buried ferrous material, particularly smaller objects, between the run lines will not have been identified within the data.

3.4.4.2 Whilst the Magnetometer data were of good quality, their usefulness for archaeological interpretation was limited due to a significant response from underlying igneous geology (discussed further in Section 9). The significant magnetic response of the igneous geology masks the typically smaller responses from anthropogenic material that may be of archaeological interest, with the exception of large features such as ferrous wrecks. Furthermore, in areas where there was a reduction in the overall magnetic response from the igneous geology the ability to differentiate between geological and potentially anthropogenic material is significantly reduced. Given the significant, and variable, magnetic response of the igneous geology it is unlikely that a change in survey methodology would have a dramatic effect on the resultant data.

3.4.4.3 **Plate 3-8** shows the residual magnetic field, following the removal of the magnetic background from the total magnetic field. The underlying igneous geology is clearly identifiable as linear features oriented approximately north-northwest, south-southeast.

3.4.4.4 The limitations of the Magnetometer data will impact the ability to undertake archaeological interpretation. However, the usefulness of magnetometer (in relation to the identification of anomalies of potential archaeological interest) is predominantly the verification of ferrous content of visible anomalies, and the identification of buried ferrous material. The SSS and MBES are of good quality and a precautionary approach to interpretation has been taken, and the overall makeup of the seabed of the Offshore Project is not conducive to the burial of material that would be considered of medium or high archaeological potential.

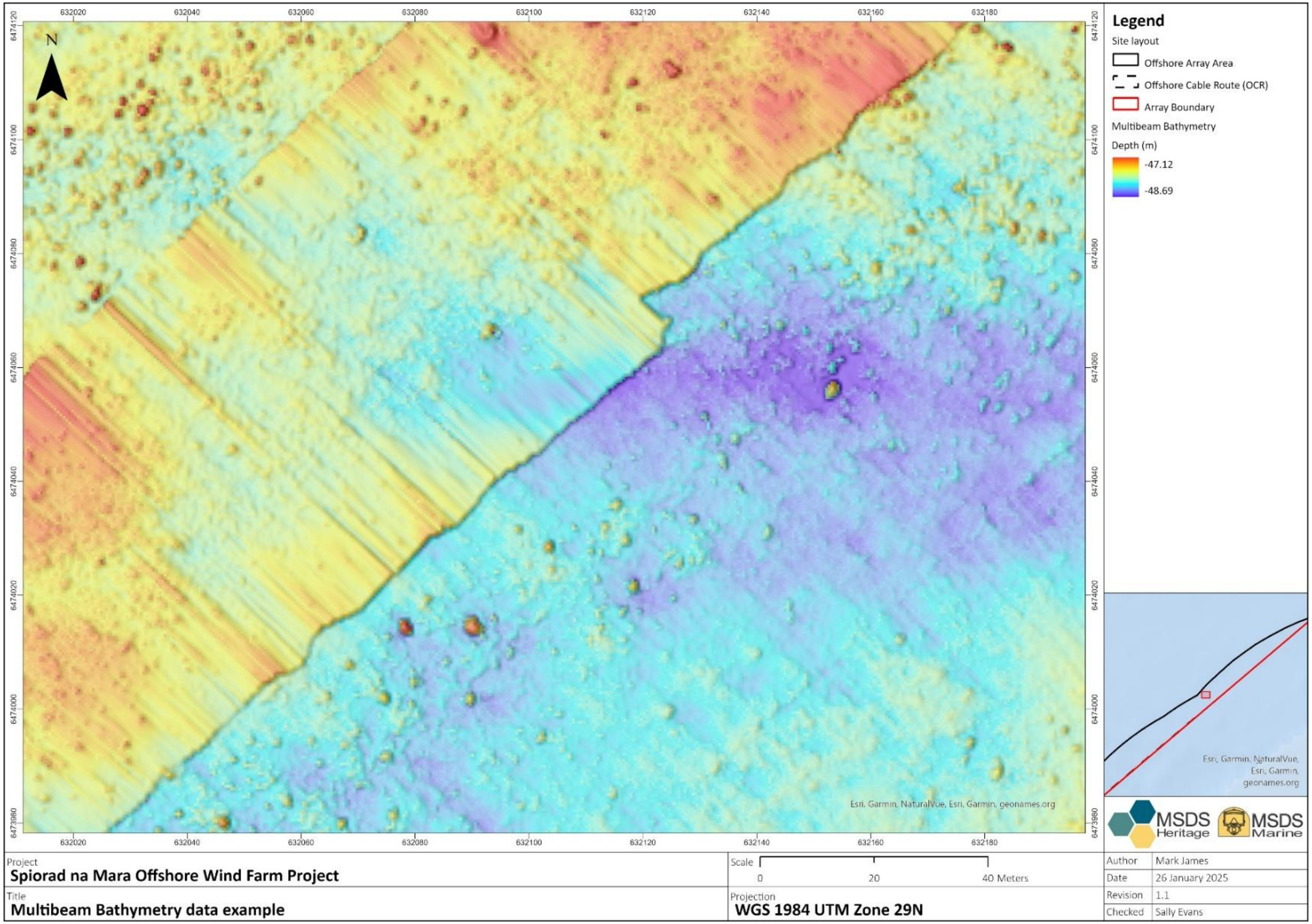


Plate 3-7 Example Multibeam Bathymetry data

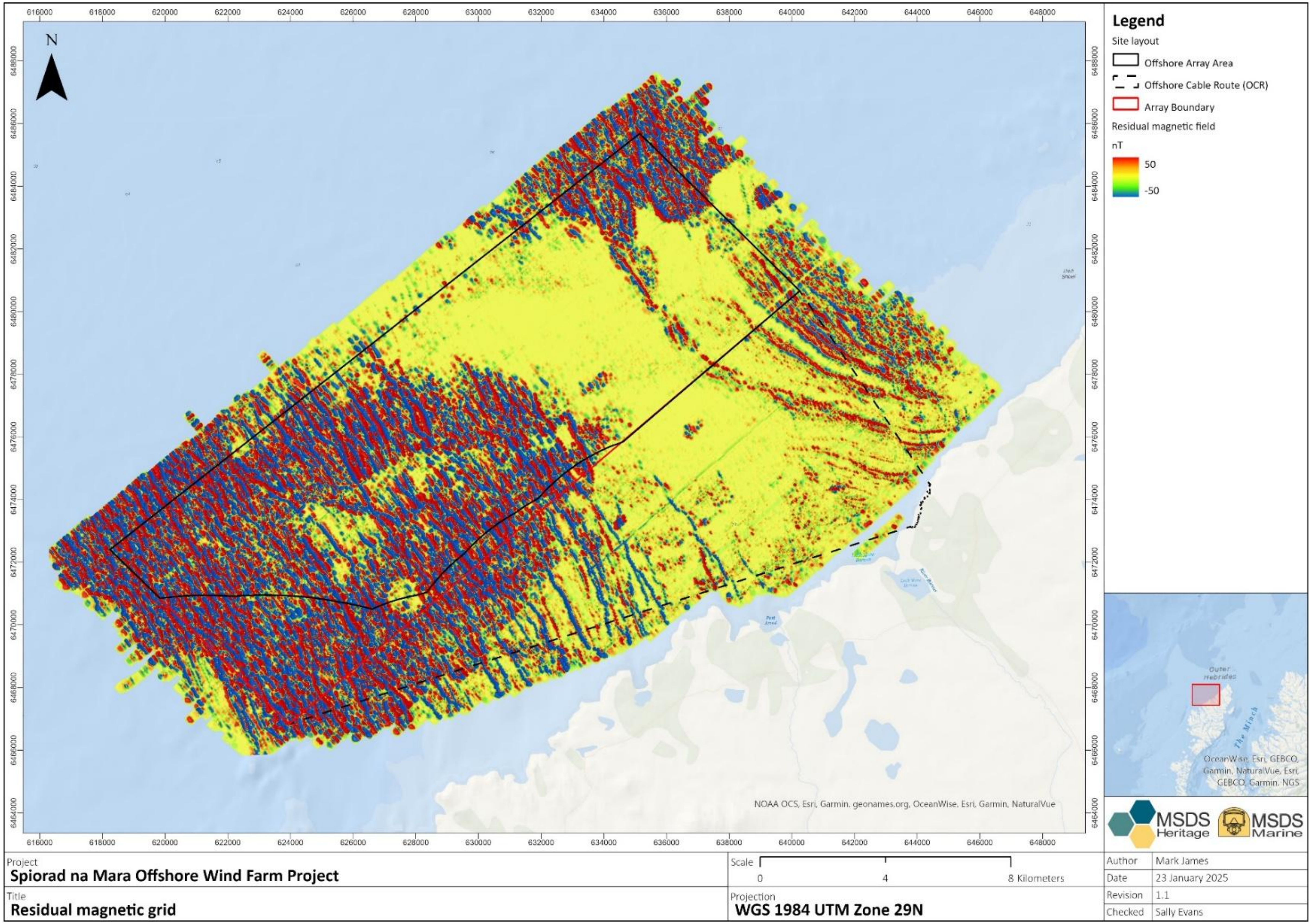


Plate 3-8 Residual magnetometer data

3.4.5 SUB-BOTTOM PROFILER

3.4.5.1 The UHRS and SBP data covered the extents of the Offshore Project (noting the unsurveyed area in the OCAS) and was collected along the pre-defined survey line plan. The data were quality assessed by Aratellus (2024) and MSDS Marine, alongside Professor Richard Bates.

3.4.5.2 Aratellus indicated that the SBP Innomar data quality from the *Glomar Supporter* was good, with penetration down to the Lewisian Gneiss bedrock, and with shallower horizons and units visible within the data. Conversely, the nearshore data collected by the *Ondine Jule* was found to be poor, limited by the shallow bedrock and hard outcrops which effected penetration and resolution. This meant that Aratellus were not able to interpret the data within the nearshore area.

3.4.5.3 The UHRS data quality from the *Glomar Supporter* was considered by Aratellus to be good, with good penetration and resolution. The UHRS data from *Ondine Jule* was also considered to be of good quality in deep waters, but in shallow waters data quality was impacted by shallow outcropping bedrock and shallow water which led to washouts along numerous lines, and geological interpretation was not possible (2024: 22).

3.4.5.4 An assessment of the suitability of the data for archaeological interpretation found that the data quality was variable. Penetration and detection of the boundary between the Quaternary sediments and earlier bedrock deposits (e.g. Lewisian Gneiss) was found to be generally good, and thus the depth of Quaternary sediment is considered well mapped within the offshore Array Area. The nearshore data covering the OCAS however was much poorer and Quaternary sediment thickness in this area was not mapped by Aratellus owing to the poor data quality (e.g. **Plate 3-9**).

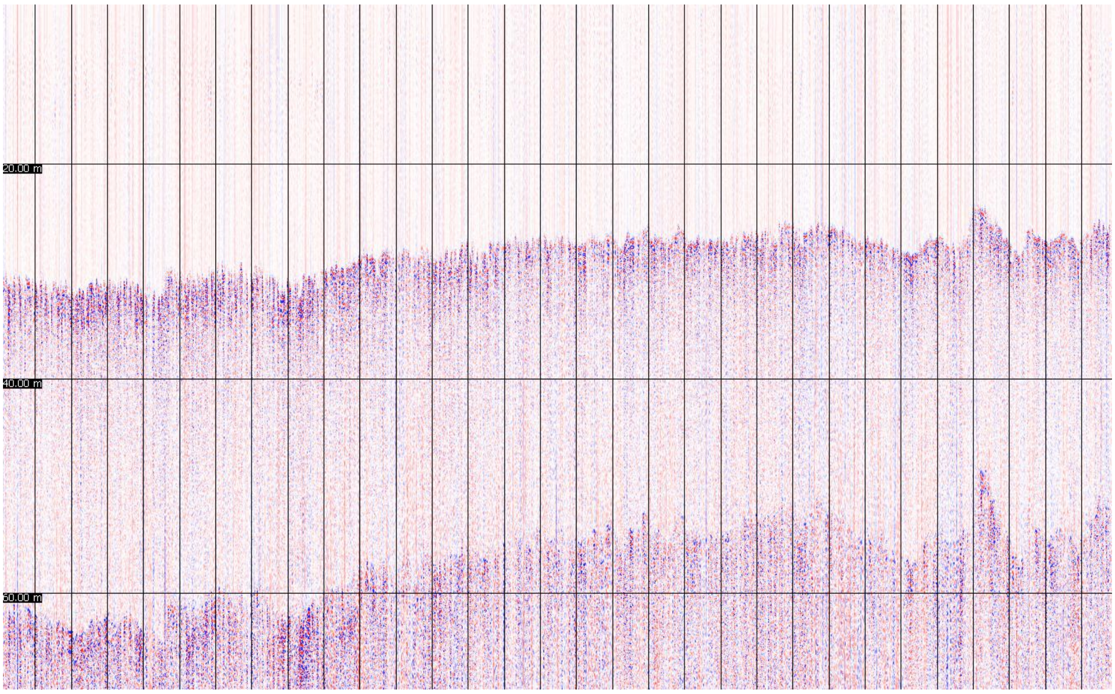


Plate 3-9 Example of the very poor nearshore data (line 01c_004_SCS_0034_NavUp_Shots)

3.4.5.5 The quality of the data and results from within the Quaternary sediment was variable. Areas of the UHRS offshore data were good, particularly in the northwest part of the Offshore Project and areas where 2 large sediment basins are mapped (**Plate 3-10**). In these areas horizon picks are considered to be accurate and correlations within the sediment sequence reasonable. However, beyond these areas' horizon picking is much more difficult (particularly in the southwest) and data quality was considered too poor to allow confident picking of individual horizons consistently across the Offshore Project.

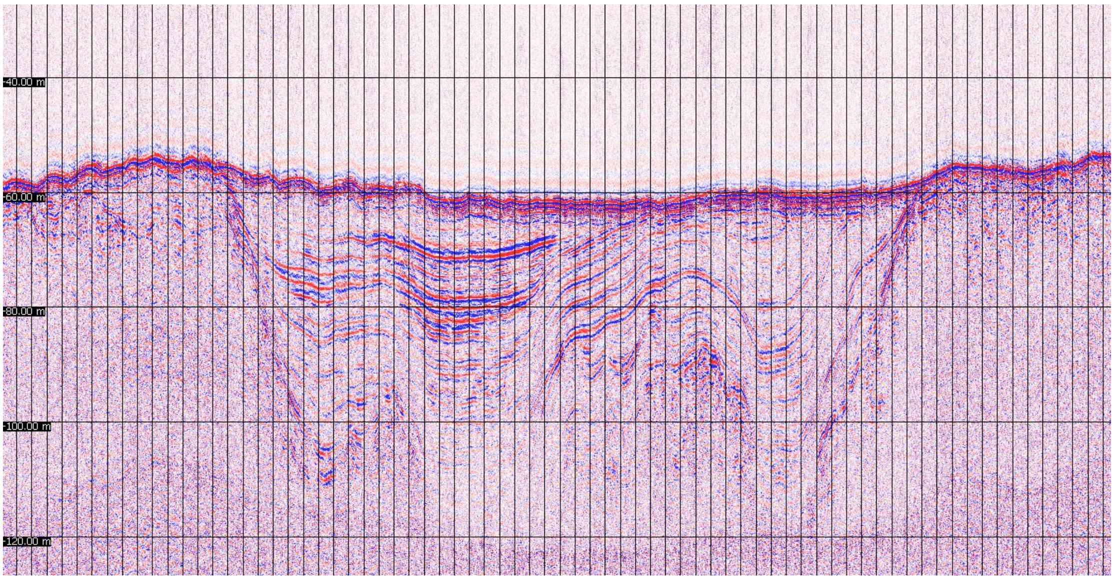


Plate 3-10 Example of the good quality data covering the basins (northern basin shown, line 15_044_UHRS0049_Final_Stack_Time)

3.4.5.6 In areas where the data quality is good enough multiple horizons could be picked. However, making geomorphological sense of these horizons is difficult in places. This is compounded by the Offshore Project (which consisted of boreholes, many of which met refusals or sample loss at shallow depths) (Aratellus, 2023). However, where data quality is sufficient, and in particular within the sediment basins within the Offshore Project, horizons were visible and could be correlated with data from the British Geological Society, allowing environmental interpretations.

3.4.5.7 MBES data was used to confirm areas of outcropping bedrock and to determine regions of archaeological potential relating to submerged palaeolandscapes.

3.4.6 SUMMARY

3.4.6.1 The data collected across the extents of the Offshore Project are of good quality overall, with the MBES data providing almost 100% coverage and the SSS data providing 200% coverage (with the exception of the unsurveyed area in the OCAS).

3.4.6.2 Due to the discussed limitations, the magnetometer data is of limited use for archaeological assessment, however the concurrent assessment of the data alongside MBES and SSS data has enabled a robust interpretation that is sufficient for the characterisation of the Historic Environment, commensurate with the requirements of an EIAR.

3.4.6.3 The UHRS and SBP data were impacted in places by the depth of water and the proximity of the bedrock to the surface. However, where data quality is sufficient, and in particular within the sediment basins within the Offshore Project, horizons were visible and could be correlated with data from the British Geological Survey (BGS), allowing environmental interpretations.

3.4.6.4 Where restrictions are noted, the data is considered of an appropriate specification, coverage, and quality, to undertake a robust archaeological assessment to inform the EIAR, noting that additional data collection, and interpretation, will be required prior to construction.

3.5 ARCHAEOLOGICAL ASSESSMENT OF DATA

3.5.1.1 The archaeological assessment of data was undertaken by a qualified and experienced maritime archaeologist with a background in geophysical and hydrographic data acquisition, processing, and interpretation.

3.5.1.2 Following delivery of the required datasets, an initial review was undertaken to gain an understanding of the geological and topographic make-up of the Offshore Project. Within the extents of the Offshore Project the potential for variations in the seabed are high and can affect the interpretation of anomalies. The assessment considers the full extents of the survey data, which was collected within a pre-defined survey boundary, including the Array Area and the OCAS. The assessment of United Kingdom Hydrographic Office (UKHO) (Admiralty Marine Data Portal 2025), Canmore (HES 2025), and Historic Environment Record (HER) data was undertaken within the extents of the survey data, relating to seabed wrecks and obstructions (UKHO) and historic environment assets, wrecks and documented sightings/experiences of historic wrecks (Canmore). These data are used to inform the interpretation of known wrecks or the likelihood of encountering physical remains relating to such.

3.5.1.3 Whilst some of the data extends beyond Offshore Project, the purpose of the assessment is to characterise the historic environment and therefore data from the wider area were considered. The focus of the mitigation measures is, however, on anomalies within the Offshore Project, or where mitigation measures would impact within the Offshore Project.

3.5.2 SIDESCAN SONAR

3.5.2.1 SSS is considered the best tool for the identification of anthropogenic anomalies on the seabed due to the ability to ensonify small features and as such forms the basis of any archaeological assessment of data. SSS data in .xtf format were imported into Moga Seaview 6.2 software, navigation and positioning were checked and corrected where required, and optimal gains were applied to ensure the consistent presentation of data.

3.5.2.2 Data were reviewed on a line-by-line basis, and all anomalies of potential anthropogenic origin identified and recorded. Records include at a minimum an image of the anomaly, dimensions, and a description. Whilst typically only images of medium and high potential anomalies are presented with the assessment report, images of all anomalies are recorded as interpretations can change as the data assessment progresses. A rating of archaeological potential was assigned to the anomaly following the criteria outlined in **Table 3-5**.

3.5.2.3 Following assessment of the individual lines, a mosaic was created and a Geotiff exported to allow for the checking of positional accuracy against the MBES data and to identify the extents of any anomalies that may have extended past the limits of individual lines.

3.5.3 MAGNETOMETER

3.5.3.1 Magnetometer data indicates the presence of ferrous, and thus usually anthropogenic, material both on, and under the seabed. Where line spacing allows, typically to a specification for the detection of potential unexploded ordnance (UXO), magnetometer data can provide accurate positions of buried ferrous anomalies. The survey line spacing is c.100 m which is too great for the accurate positioning of magnetic anomalies at distances away from the tracklines but can indicate areas of archaeological potential. Where possible, magnetic anomalies were correlated with anomalies visible on the seabed.

3.5.3.2 Magnetometry data were provided as .csv files and as a gazetteer detailing all anomalies greater than 5 nT. An assessment was made by MSDS Marine as to the suitability of the gazetteer for archaeological interpretation. Where required the .csv magnetometer data were imported into Moga Seaview 6.2 software where the data were smoothed, and a 'baseline' identified and removed from the data to highlight ferrous anomalies whilst taking into account geological variations in the data.

3.5.3.3 Magnetic anomalies identified within the data had the position, amplitude, and dimensions recorded. A rating of archaeological potential was assigned to the anomaly following the criteria outlined in **Table 3-5**. The data were gridded to visually identify areas where the distribution of anomalies may represent a wider feature such a buried but dispersed wreck, or modern features such as buried cable or chain.

3.5.4 MULTIBEAM BATHYMETRY

3.5.4.1 Due to the minimum anomaly detection size of MBES data being larger than that of SSS data, the primary use during archaeological assessment, outside of seabed characterisation, is the corroboration of anomalies identified within other datasets and the visualisation of anomalies that may otherwise be obscured by shadow.

3.5.4.2 Navigation corrected, but unprocessed, MBES data were provide to MSDS Marine as .xyz files, the data were imported into QPS Fledermaus where it was gridded and exported as a depth embedded raster, the raster was imported into ArcGIS Pro 3.4 and a hill-shaded surface applied, shading was adjusted to ensure the optimal presentation of data. The resulting 3-Dimensional image was viewed on a block-by-block basis, and all anomalies of potential anthropogenic origin identified and recorded.

3.5.4.3 Records include, at a minimum, an image of the anomaly, dimensions, and a description. A rating of archaeological potential was assigned to the anomaly following the criteria outlined in **Table 3-5**. Where the interpretation of an anomaly was unclear, the data were imported into point cloud visualisation software such as Cloud Compare, in order to view the un-gridded data. The gridded surface image was exported as a Geotiff to allow further assessment alongside other datasets.

Table 3-5 Criteria for the assessment of archaeological potential

Potential	Criteria
Low	An anomaly potentially of anthropogenic origin but that is unlikely to be of archaeological significance – Examples may include discarded modern debris such as rope, cable, chain, or fishing gear; small, isolated anomalies with no wider context; or small boulder-like features with associated magnetometer readings.
Medium	An anomaly believed to be of anthropogenic origin but that would require further investigation to establish its archaeological significance – Examples may include larger unidentifiable debris or clusters of debris, unidentifiable structures, or significant magnetic anomalies.
High	An anomaly almost certainly of anthropogenic origin and with a high potential of being of archaeological significance – high potential anomalies tend to be the remains of wrecks, the suspected remains of wrecks, or known structures of archaeological significance.

3.5.5 COMBINED ASSESSMENT

3.5.5.1 Following the assessment of all datasets the results were loaded into ESRI ArcGIS Pro 3.4, a Geographical Information System (GIS), and reviewed alongside each other, along with Geotiffs of the SSS, MBES, and Magnetometer data. The concurrent review allows the amalgamation of duplicate anomalies, the assessment of the wider context, and an understanding of the extents of a feature that may be partially buried or span across two or more lines of data.

3.5.5.2 Data from the UKHO, including the positions of wrecks and obstructions, and Canmore, as well as all other relevant data such as third-party assets (see Section 2) were assessed to ensure that any additional information is drawn upon, but also that anomalies are not unnecessarily identified as having archaeological potential when the origination can be identified. The resultant remaining anomalies assessed as having archaeological potential were compiled into a gazetteer and a shapefile.

3.5.5.3 The interpretation of geophysical and hydrographic data is, by its very nature, subjective. However, with experience and by analysing the form, size, and characteristics of an anomaly, a reasonable degree of certainty as to the origin of an anomaly can be achieved.

3.5.5.4 Measurements can be taken in most data processing software, and whilst largely accurate, discrepancies can be noted due to a number of factors. Where there is uncertainty as to the potential of an anomaly, or its origin, a precautionary approach is always taken to ensure the most appropriate mitigation for the historic environment.

3.5.5.5 It should be noted that there may be instances where an anomaly may exist on the seabed but not be visible in the geophysical data. This may be due to being covered by sediment or being obscured from the line of sight of the sonar. The use of both SSS and MBES data mitigates this by visualising anomalies from multiples angles, including from above. Anomalies were named following the standard MSDS Marine convention, [PROJECTYEAR_ID], e.g., SP24_XXX.

3.6 PALAEOLANDSCAPE AND SUB-BOTTOM PROFILER SOURCES

3.6.1.1 A number of data sources were used for the assessment. The principal sources which were reviewed and assessed are set out below, while other published sources are referred to in-text.

3.6.1.2 The data available for the Offshore Project includes:

- BGS Offshore Regional Report (ORR) (Stoker *et al.*, 1993);
- BGS geological maps 1:250,000 series;
- Interpretation report: Aratellus, 2024: Spiorad na Mara Offshore Wind Farm: ARA-0087-ENG-OND-005: Geophysical Factual Report;
- Geotechnical report: Aratellus 2023: Spiorad na Mara Offshore Wind Farm – 2023 Geotechnical Survey: Geotechnical Factual Data Report (Final);
- Geoarchaeological report: Northland Power, 2024. Spiorad na Mara offshore wind farm project. Stage 1 Geoarchaeological Review of Geotechnical Data.

3.7 PALAEOLANDSCAPE AND SUB-BOTTOM PROFILER INTERPRETATION

3.7.1.1 Whilst the interpretation of the palaeolandscape is based upon the archaeological review of geophysical and hydrographic data, the method of assessment, the assessment criteria and the best practise mitigation strategies differ from those presented in the preceding sections and thus it is detailed separately for clarity.

3.7.1.2 Sub-surface data acquired from seismic and geotechnical surveys is key to understanding the palaeolandscape potential of the Offshore Project. These data have been collected for the Offshore Project, reviewed, and brought into an assessment which details geological conditions within the Offshore Project. The interpretations of the data have fed into the ground model, which incorporates both geological modelling and engineering conditions, knowledge of which is necessary for development design. Sedimentary units have been identified within the ground model and tentatively correlated with known geological formations in the area based on the available data.

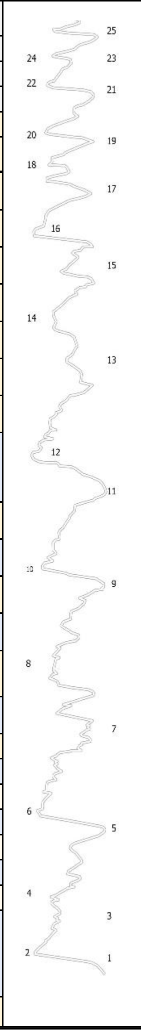
3.7.1.3 From an archaeological perspective the ground model provides insight into the potential geological formations within the Offshore Project, and their likely depositional environment. This feeds into the assessment of the palaeolandscape through time, and corresponding archaeological potential. Information from the ground model and geological maps derived from the interpretation of sub-surface data and the current seabed derived from MBES data were assessed alongside existing studies which contribute to the understanding of the palaeolandscape and prehistoric archaeological potential within the Offshore Project.

3.7.1.4 An archaeological review of the ground model covering Offshore Project was conducted by MSDS Marine supported by Professor Richard Bates. This included a review of geophysical survey data, reports, seismic profiles and ground model outputs including geological profiles at well locations. These sources were reviewed in order to establish the suitability of the data for archaeological interpretation and to gain an understanding of the geological make-up of the Offshore Project, formations present and their palaeoenvironmental and archaeological potential. Information about the wider area has also been used to better contextualise the various environments experienced in the area during the Pleistocene and Holocene.

3.7.1.5 The assessment of submerged prehistoric remains seeks to identify periods in which the Offshore Project was dry land, and thus inhabitable, and periods in which the area lay under ice sheets or water masses, rendering Offshore Project uninhabitable. Different geological formations are also associated with differing environmental conditions, and thus different archaeological potential and the report therefore investigates the Quaternary sequence within the Offshore Project. The assessment also seeks to identify the previous environmental characteristics of the Offshore Project and Study Area (e.g., marine, terrestrial, lacustrine, fluvial, marsh, riverine etc.) at different times during the Quaternary period, as this is key to understanding palaeolandscape and paleoenvironmental potential, and also to how past human populations may have used the areas. Determining the potential for remains to survive is equally important. This involves consideration of the current geological makeup of the area, along with the effects of erosion and other geological forces, following the succession of glaciations and marine transgressions which have shaped the area.

3.7.1.6 The Quaternary chronology of the UK, used for the assessment of submerged prehistory is set out in **Table 3-6**. Marine Isotope Stages (MIS) are alternating warm and cold periods derived from oxygen isotope data taken from deep sea core samples.

Table 3-6 Criteria for the assessment of archaeological potential

Stage			Age		Climate	Marine Isotope Stage		Epochs and Periods		
Main	Sub.		Start	End		Stages	Record			
Beestonian			970,000	936,000	Interglacial	25		Pleistocene	Early Pleisto.	Lower Palaeolithic
			936,000	917,000		24				
			917,000	900,000	Interglacial	23				
			900,000	866,000	Stadial	22				
			866,000	814,000	Sequence poorly understood but evidence for a series of small expansions of the British Ice Sheet marking at least 4 interstadials and 5 warm episodes.	21				
			814,000	790,000		20				
Bruhnes-Matuyama reversal (c. 780kBP) Cromerian Complex			790,000	761,000		19			Middle Pleistocene	
			761,000	712,000		18				
			712,000	676,000		17				
			676,000	621,000		16				
			621,000	563,000		15				
			563,000	524,000		14				
			524,000	478,000		13				
Anglian			478,000	424,000	Stadial	12				
Hoxnian			424,000	374,000	Interglacial	11				
Wolstonian/ Saalian complex	Unnamed		374,000	337,000	Stadial?	10				
	Purfleet		337,000	300,000	Interglacial	9				Middle Palaeolithic
	Early		300,000	243,000	Stadial?	8				
	Aveley		243,000	191,000	Interglacial	7				
	Late		191,000	123,000	Stadial	6				
Ipswichian			123,000	109,000	Interglacial	5e			Late Pleistocene	
Devensian	Early		109,000	96,000	Stadial	5d				
		Chelford	96,000	87,000	Interstadial	5c				
			87,000	82,000	Stadial	5b				
		Brimpton	82,000	71,000	Interstadial	5a				
			71,000	57,000	Stadial	4				
	Mid	Upton Warren	57,000	29,000	Interstadial	3				Upper Pal
	Late	Dimlington	29,000	14,700	Stadial	2				
		Windemere	14,700	12,900	Interstadial					
		Loch Lomond	12,900	11,700	Stadial					
Holocene			11,700	Present	Interglacial	1		Holocene		Meso.

3.8 MITIGATION (METHODOLOGY)

3.8.1.1 The following section discusses the archaeological mitigation strategies which are considered for the Offshore Project, the proposed mitigation is presented in Section 10.

3.8.2 SURFACE ANOMALIES

3.8.2.1 To ensure the most appropriate and robust mitigation for the historic environment, whilst being proportional to the requirements of the development, mitigation recommendations are determined on an anomaly-by-anomaly basis, and consider all available data including:

- Potential significance;
- Size;
- Seabed type;
- Seabed dynamics;
- Development type;
- Potential negative impacts.

3.8.2.2 Mitigation strategies have been based on the criteria in **Table 3-7**.

Table 3-7 Mitigation criteria for archaeological anomalies

Potential	**Criteria**
Low	No archaeological significance interpreted, and a low potential to be of archaeological significance. Maintain an operational awareness of the anomaly's location and reporting through the agreed protocol should material of potential archaeological significance be encountered.
Medium	Avoidance of the anomaly's position and where appropriate an archaeological exclusion zone may be recommended. Ground truthing of the anomaly through the use of divers or a Remotely Operated Vehicle (ROV) would establish the archaeological potential.
High	Archaeological exclusion zones will be recommended based on the size of the anomaly, any outlying debris and the seabed dynamics as interpreted from the SSS, MBES, and magnetometer data.

3.8.2.3 Where an anomaly is visible in the MBES data, that position will generally be used for the implementation of mitigation recommendations. The position obtained from the MBES data is generally more accurate due to the sensor and the GPS receiver being fixed to the vessel in known planes. SSS and magnetometer sensors are towed, and thus the margin for error is greater even with USBL, as the positional tolerance can be between 0.5 m and 2.0 m.

3.8.2.4 A phased approach to mitigation is proposed for the Offshore Project, corresponding with the planned future survey strategy. The survey specification was designed for the purposes of consenting and project planning to determine the most appropriate area for development. Future surveys will likely combine an increase in resolution, and the addition of magnetometer data with tighter line spacing (as determined by the pUXO risk), within the

Array Area. With the data resolution and coverage set to increase, the confidence in interpretation and appropriateness of mitigation strategies will also increase. Following the archaeological assessment, recommendations have been made as to the coverage and specification of future surveys to ensure a robust archaeological assessment of the development area at all stages of the development process.

3.8.2.5 At this phase, differentiation has made between anomalies that are visible and identifiable in the survey data (e.g., SSS and MBES anomalies), and potential anomalies that have not been identified in the survey data but are likely to exist on the seabed (e.g., Live UKHO records).

3.8.2.6 The mitigation strategies detailed in **Table 3-8** have been used.

Table 3-8 Archaeological mitigation strategies

Potential	Criteria
Archaeological Exclusion Zones (AEZs)	For archaeologically significant anomalies that are clearly identifiable in the survey data and where the extents are largely known, Archaeological Exclusion Zones (AEZs) will be recommended. AEZs will remain for the life of the Offshore Project or until ground truthing or higher resolution data determines a reduction in potential, significance, or extents.
Temporary Archaeological Exclusion Zones (TAEZs)	Where an anomaly is not visible in the survey data but likely to exist on the seabed at a known position or where the extents of an anomaly are not fully identifiable, Temporary Archaeological Exclusion Zones (TAEZs) will be recommended. TAEZs have been identified as highly likely to be altered following higher resolution or full coverage data assessment, however, they will remain in place until alterations have been formally agreed.
Areas of Archaeological Potential (AAP)	Areas of Archaeological Potential (AAP) are primarily reserved for magnetic anomalies where, due to line spacing, positions are not accurately known. AAPs demonstrate that there is potentially an anomaly of archaeological significance around the given position. The anomaly is likely to be identified following higher resolution or full coverage data assessment but as the nature and position is not precisely known, no formal exclusion zone is recommended but instead a general awareness of the position is considered appropriate at this phase.

3.8.3 PALAEOLANDSCAPE

3.8.3.1 Dependent on the assessed potential, the process of mitigation in relation to the palaeolandscape and palaeoenvironmental remains typically follows a staged approach of continued assessment aligning with the engineering requirement to undertake geotechnical works. The staged process is broadly outlined within The Crown Estate (2021) guidance on

Archaeological Written Schemes of Investigation for Offshore Wind Farm Projects and COWRIE (Gribble and Leather 2011) guidance on *Offshore Geotechnical Investigations and Historic Environment Analysis*.

3.8.3.2 Archaeological input into geotechnical core locations can allow for the greatest insights into the palaeolandscape, such as through the sampling of stratified channel deposits, deposits likely to contain organic remains or un-eroded surfaces. Typically, this process involves close collaboration with the Site Investigation team. Round-table discussions and the review of seismic profiles tends to be a conducive method of allowing engineering and archaeological requirements to be taken into consideration when micro-siting geotechnical cores.

3.8.3.3 Archaeological input into the planning of core locations is not essential, however, and sufficient information can be gained from the sharing of derived data, such as core logs, photographs and soil descriptions. This data has been gathered for the Offshore Project and will be archaeologically assessed as part of the forthcoming impact assessment.

3.8.3.4 Following the collection of geotechnical cores, they will typically undergo a staged program of geoarchaeological assessment and analysis. In brief the process is as follows:

- Stage 1: Geoarchaeological review of core logs;
- Stage 2: Geoarchaeological recording;
- Stage 3: Geoarchaeological assessment;
- Stage 4: Geoarchaeological analysis;
- Stage 5: Final reporting and publication.

4 RESULTS OF SURFACE GEOPHYSICAL ANOMALIES

4.1.1.1 For the avoidance of confusion, the results of magnetic anomalies with no surface expression are presented in Section 5, UKHO records in Section 6, Canmore records in Section 7, HER records in Section 8, and the palaeolandscape assessment in Section 9.

4.1.1.2 A total of 25 surface anomalies of potential archaeological interest were identified within the geophysical survey data extents, of which 9 are within the Array Area and 11 within the OCAS. The remaining 5 anomalies are located within the data extents. The anomalies are categorised by potential in **Table 4-1**.

Table 4-1 : Distribution of archaeological anomalies by potential

Potential	Array	OCAS	Data extents	Total
Low	7	10	4	21
Medium	2	1	1	4
High	0	0	0	0
Total	9	11	5	25

4.1.1.3 The distribution of anomalies is shown in **Plate 4-1**, as can be noted the distribution is fairly irregular across the surveyed area, predominantly consistent with areas of exposed bedrock or areas with high densities of boulders. The distribution highlights the more precautionary approach required in such areas.

4.1.1.4 The distribution of anomalies within the geophysical data shows a consistent approach to the assessment. The identified anomalies are discussed below according to their assessed potential.

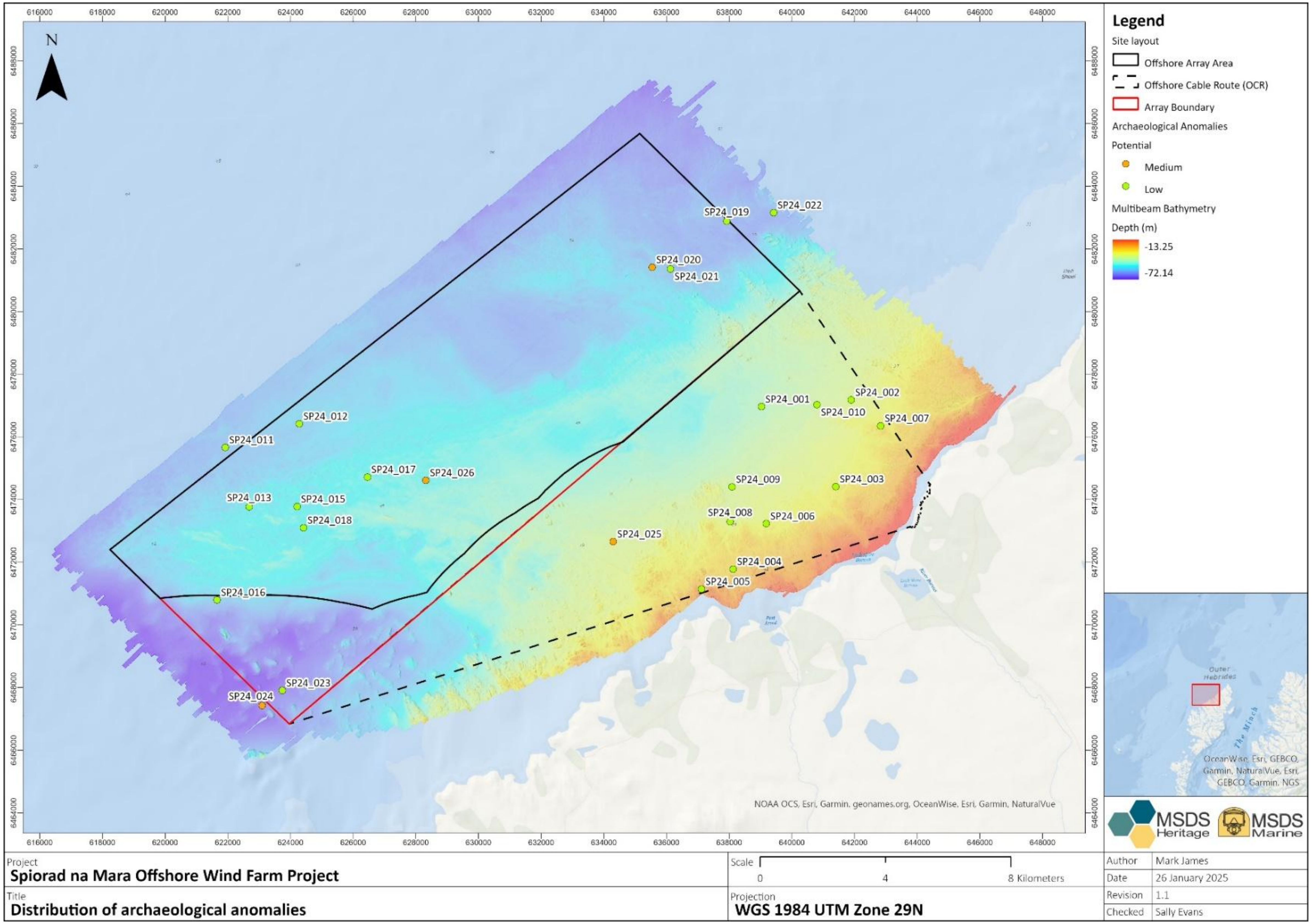


Plate 4-1 Distribution of Archaeological Anomalies

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4.2 LOW POTENTIAL ANOMALIES

4.2.1.1 21 anomalies interpreted as of low archaeological potential were identified within the geophysical survey data extents, of which 7 are within the Array Area and 10 within the OCAS. The remaining 4 anomalies are located within the data extents. The anomalies can be categorised as follows in **Table 4-2**.

Table 4-2 Low potential anomaly categories

Anomaly Category	Array	OCAS	Data Extents	Total
Chain, Cable, or Rope	1	0	0	1
Likely Geological	4	6	1	11
Potential Debris	1	4	2	7
Mound	1	0	0	1
Seabed Disturbance	0	0	1	1
Total	7	10	4	21

4.2.1.2 The anomalies interpreted as of low archaeological potential (see **Table 3-5**) are a mixture of small features, often boulder-like, or likely to represent modern debris such as chain, cable, or rope, or small items of potential debris with no features indicating archaeological potential. Each anomaly was reviewed and interpreted to be of low archaeological potential. A further review was undertaken following the assessment of the survey area extents.

4.2.1.3 The high proportion of anomalies interpreted as 'likely geological' is indicative of the nature of the seabed, and the high density of boulders across a significant percentage of the Offshore Project. In such areas, coupled with the magnetometer dataset influenced by the effects of igneous geology, a precautionary approach has been taken.

4.2.1.4 **Table 4-3** provides a brief justification for the interpretation of each category of low potential anomalies. To note, the descriptions below are generalised, and each anomaly is interpreted based on individual characteristics, other anomalies within the wider area, seabed characterisation, etc.

Table 4-3 Low potential anomaly descriptions

Anomaly Category	Description
Chain, Cable, or Rope	Features identified as chain, cable, or rope are generally identified as long, linear, or curvilinear features with little or no measurable height. The length and form will generally preclude their assessment as of a higher archaeological potential.
Likely Geological	Features identified as likely geological, are generally precautionary identifications where the form is indictive of a geological feature but may be of a size, or form, which is unusual in the surrounding area.
Potential Debris	Features identified as potential debris will generally display characteristics indicating anthropogenic origin, such as straight or angular edges. Boulder like features, with associated magnetic anomalies can also be categorised as potential debris.
Mound	Features identified as mounds will generally be of a form that may indicate either buried, or partially buried, anthropogenic material. The size and form of the mound, alongside the relationship to other features on the seabed will determine the archaeological potential.

4.2.1.5 Low potential anomalies have been assessed against all available evidence and are deemed unlikely to be of archaeological significance and as such are not discussed further within the results section of this report. The identification of an anomaly as of low archaeological potential is commensurate with the mitigation for this category - *Maintain an operational awareness of the anomaly's location and reporting through the agreed protocol should material of potential archaeological significance be encountered*.

4.2.1.6 The distribution of low potential anomalies is shown in **Plate 4-2**. Further information regarding mitigation can be found in Section 10, and a gazetteer of low potential anomalies, including positions and dimensions, can be found in **Annex 15.1.2.A: Anomalies of Archaeological Potential, Volume 2c**.

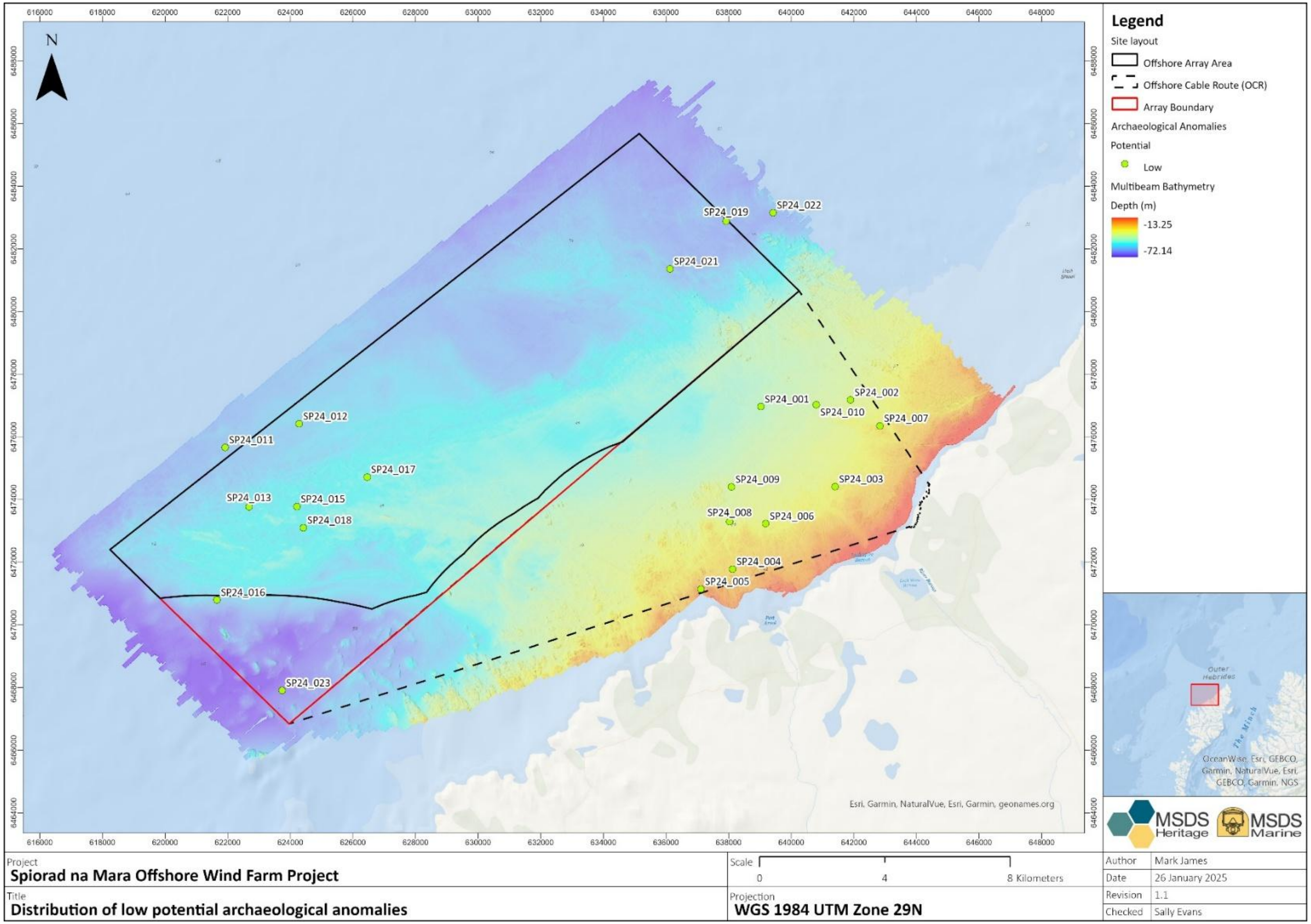

Plate 4-2 Distribution of Low Potential Archaeological Anomalies

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4.3 MEDIUM POTENTIAL ANOMALIES

4.3.1.1 A total of 4 anomalies interpreted as of medium archaeological potential were identified within the geophysical survey data extents, of which 2 are within the Array Area and 1 within the OCAS. The remaining anomaly is located within the data extents. The anomalies can be categorised as follows in **Table 4-4**, the distribution is presented in **Plate 4-3**.

Table 4-4 Medium potential anomaly categories

Anomaly Category	Array	OCAS	Data Extents	Total
Potential Debris	1	1	0	2
Mound	1	0	1	2
Total	2	1	1	4

4.3.1.2 The anomalies interpreted as of medium archaeological potential have characteristics that indicate a likelihood of representing anthropogenic material that has the potential to be of archaeological interest, or where a precautionary approach has been taken.

4.3.1.3 The identification of an anomaly as of medium archaeological potential is commensurate with the mitigation for this category - Avoidance of the anomaly's position and where appropriate an archaeological exclusion zone may be recommended. Ground truthing of the anomaly through the use of divers or an ROV would establish the archaeological potential.

4.3.1.4 The medium potential anomalies are discussed, along with images, within this section of this report. Further information regarding mitigation can be found in Section 10, and a gazetteer of medium potential anomalies, including positions and dimensions can be found in **Annex 15.1.1: Historic Environment Gazetteer, Volume 2c**.

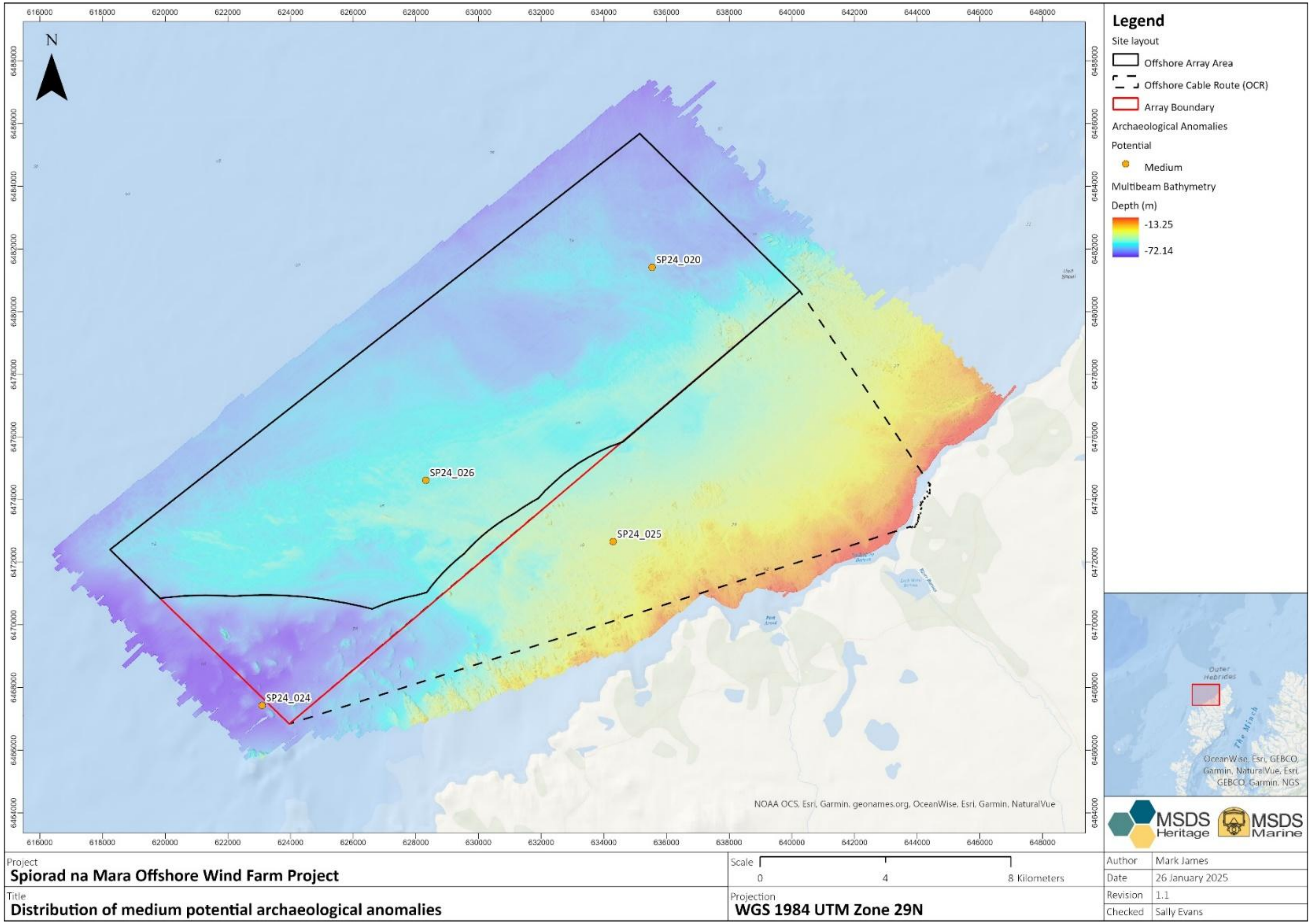

Plate 4-3 Distribution of Medium Potential Archaeological Anomalies

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4.3.2 MEDIUM POTENTIAL SP24_020

4.3.2.1 SP24_020 (**Plate 4-4**) lies within the Array Area, c. 4.3 km south of the northern most corner. The anomaly is visible in both the SSS and MBES data but has no associated magnetic anomaly. The anomaly lies c. 30 m from the closest magnetometer trackline, at that distance a ferrous mass of c.13,500 kg would equate to an amplitude of 5.0 nT (assuming a 1:1 aspect ratio). Due to the effect of the underlying igneous geology, it has not been possible to identify small magnetic anomalies, therefore the absence of a magnetic anomaly in relation to SP24_020 does not confirm the absence of ferrous material. The anomaly does not correspond with any UKHO or Canmore records, the closest being UKHO 102274 which lies 4.0 km to the west.

4.3.2.2 The anomaly is characterised by a cluster of 3 prominent and irregular features covering an area 9.2 m x 6.3 m with a measurable height of 1.2 m. Slight, but localised, scour is visible amongst the features. The 2 features to the southeast potentially represent one larger feature with a linear depression in the centre, however this is not clear within the MBES or the SSS data. The origin of the anomaly is not clear, and it lies within an area of seabed characterised by the presence of boulders. However, the individual features of the anomaly are notably larger in size than the boulders in the vicinity, and of an overall form and size that may indicate anthropogenic origin, and a medium archaeological potential.

4.3.3 MEDIUM POTENTIAL SP24_024

4.3.3.1 SP24_024 (**Plate 4-5**) lies outside the Offshore Project, c. 1.0 km northwest of the western most corner of the OCAS. The anomaly is visible in both the SSS and MBES data but has no associated magnetic anomaly. The anomaly lies c. 38 m from the closest magnetometer trackline, at that distance a ferrous mass of c.27,500 kg would equate to an amplitude of 5.0 nT (assuming a 1:1 aspect ratio). Due to the effect of the underlying igneous geology, it has not been possible to identify small magnetic anomalies, therefore the absence of a magnetic anomaly in relation to SP24_024 does not confirm the absence of ferrous material. The anomaly does not correspond with any UKHO or Canmore records, the closest being UKHO 102274 which lies 15.3 km to the northeast.

4.3.3.2 The anomaly is visible in both the SSS and MBES data as a prominent mound measuring 36.4 m x 16.8 m with a measurable height of 2.8 m, there is no significant scour around the anomaly. The mound is broadly oval in shape with an irregular surface, and orientated northeast to southwest. The anomaly is in an area of outcropping bedrock, however the form and the orientation differ from the surrounding geological features. Mounds can represent buried (or partially buried) anthropogenic material, or for example, the more robust elements of wrecks such as ballast or non-organic cargos. The size and form of the mound, and the noted differences to other geological features means a medium potential rating is considered appropriate.

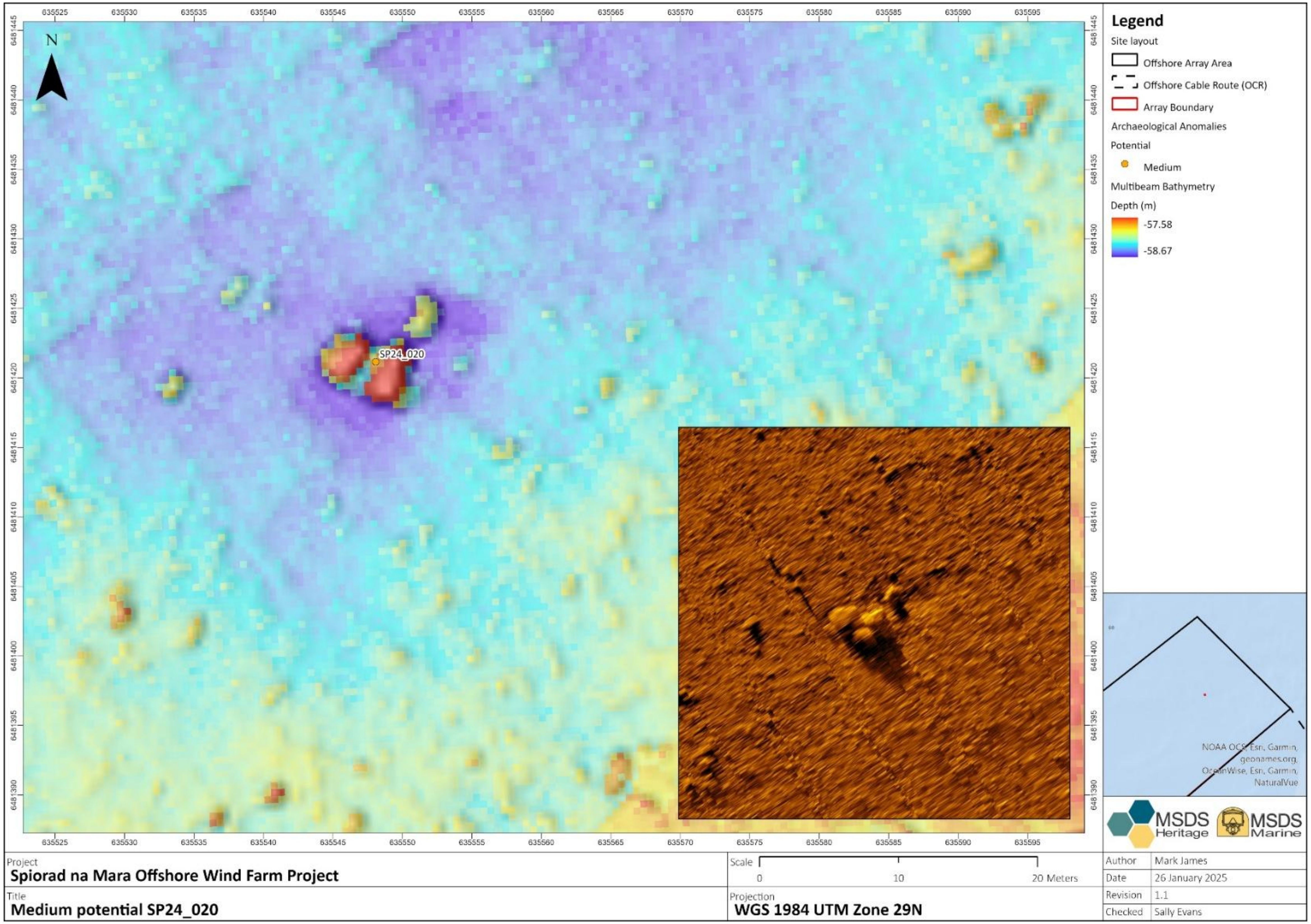

Plate 4-4 Medium potential SP24_020

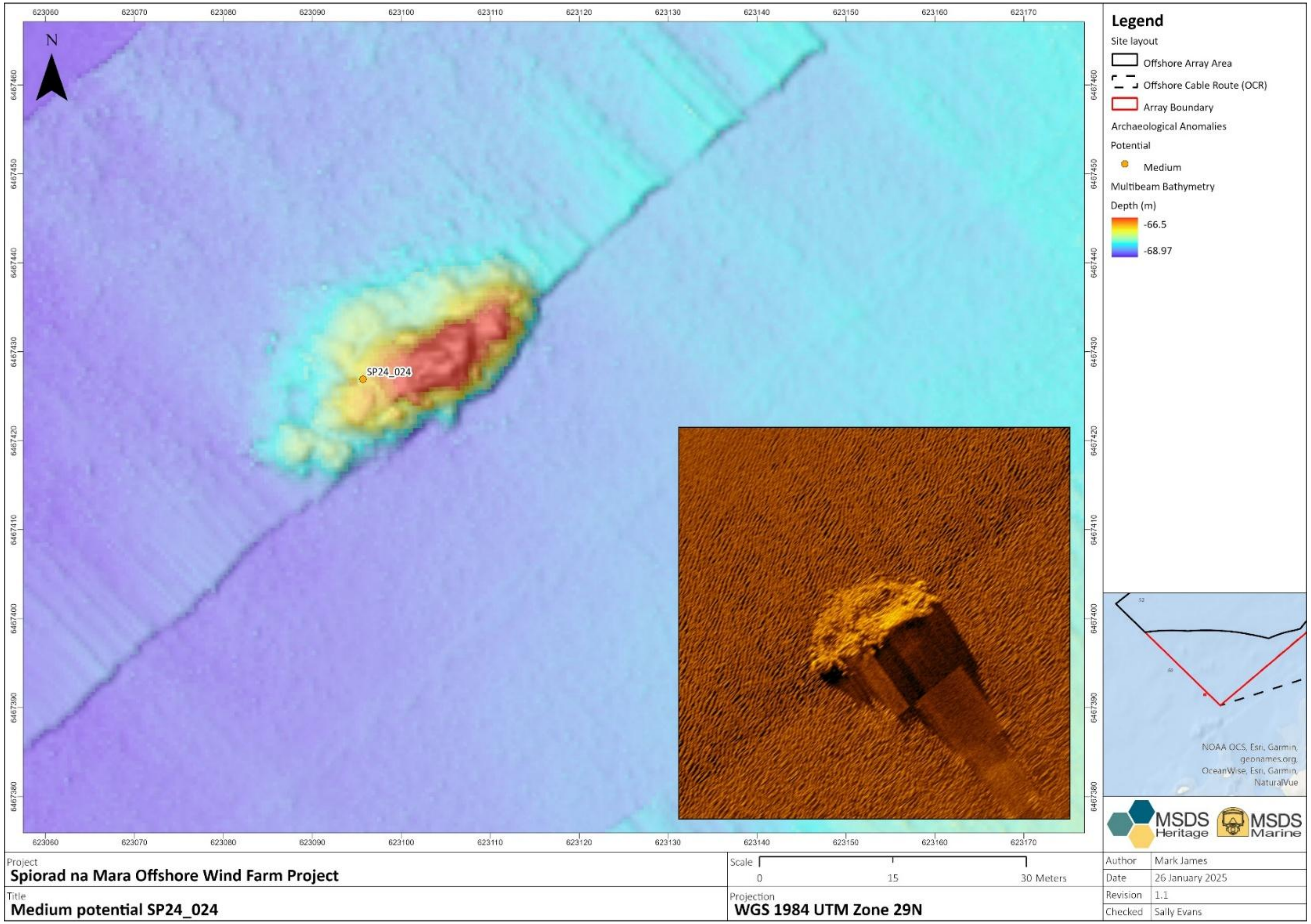

Plate 4-5 Medium potential SP24_024

4.3.4 MEDIUM POTENTIAL SP24_025

4.3.4.1 SP24_025 (**Plate 4-6**) lies within the OCAS, c. 2.3 km from the northwestern boundary. The anomaly is visible in both the SSS and MBES data but has no associated magnetic anomaly. The anomaly lies c. 27 m from the closest magnetometer trackline, at that distance a ferrous mass of c.10,000 kg would equate to an amplitude of 5.0 nT (assuming a 1:1 aspect ratio). Due to the effect of the underlying igneous geology, it has not been possible to identify small magnetic anomalies, therefore the absence of a magnetic anomaly in relation to SP24_025 does not confirm the absence of ferrous material. The anomaly does not correspond with any UKHO or Canmore records, the closest being Canmore 260521 which lies 3.5 km to the south.

4.3.4.2 The anomaly is characterised by 2 parallel, and separated, linear features orientated north to south., the feature to the east measuring 9.9 m x 2.3 m and the feature to the west measuring 7.4 mx 2.2 m. The overall height, from the lowest point of the seabed to the highest point of the feature, measures 2.1 m. The seabed height is variable in the immediate vicinity, however, scour that appears to have been caused by the anomaly is visible to north of the eastern feature, potentially extending northwest and southeast.

4.3.4.3 The anomaly is located within an area of dense boulders, 2 within 100 m are >5.0 m, and there is potential that it is geological in origin. However, the form is different to the surrounding boulders and may indicate anthropogenic origin of a size that could be of archaeological interest. Therefore, a precautionary medium potential rating has been assigned.

4.3.5 MEDIUM POTENTIAL SP24_026

4.3.5.1 SP24_026 (**Plate 4-7**) lies within the Array Area, c. 10.3 km east of the western most corner. The anomaly is visible in both the SSS and MBES data but has no associated magnetic anomaly. The anomaly lies c. 39 m from the closest magnetometer trackline, at that distance a ferrous mass of c.2,700 kg would equate to an amplitude of 5.0 nT (assuming a 1:1 aspect ratio). Due to the effect of the underlying igneous geology, it has not been possible to identify small magnetic anomalies, therefore the absence of a magnetic anomaly in relation to SP24_026 does not confirm the absence of ferrous material. The anomaly does not correspond with any UKHO or Canmore records, the closest being UKHO 102274 which lies 6.4 km to the northeast.

4.3.5.2 The anomaly is visible in both the SSS and MBES data a large, prominent, feature measuring 8.4 m x 6.1 m with a measurable height of 2.4 m. Scour is visible all around the anomaly but is more prominent to the south. The anomaly lies within an area of similar features, interpreted as boulders. However, it is notably larger and more irregular in shape and potentially comprised of three separate elements which may suggest anthropogenic origin. The anomaly has been assigned a precautionary medium potential rating due to differences to the surrounding geological features and the size.

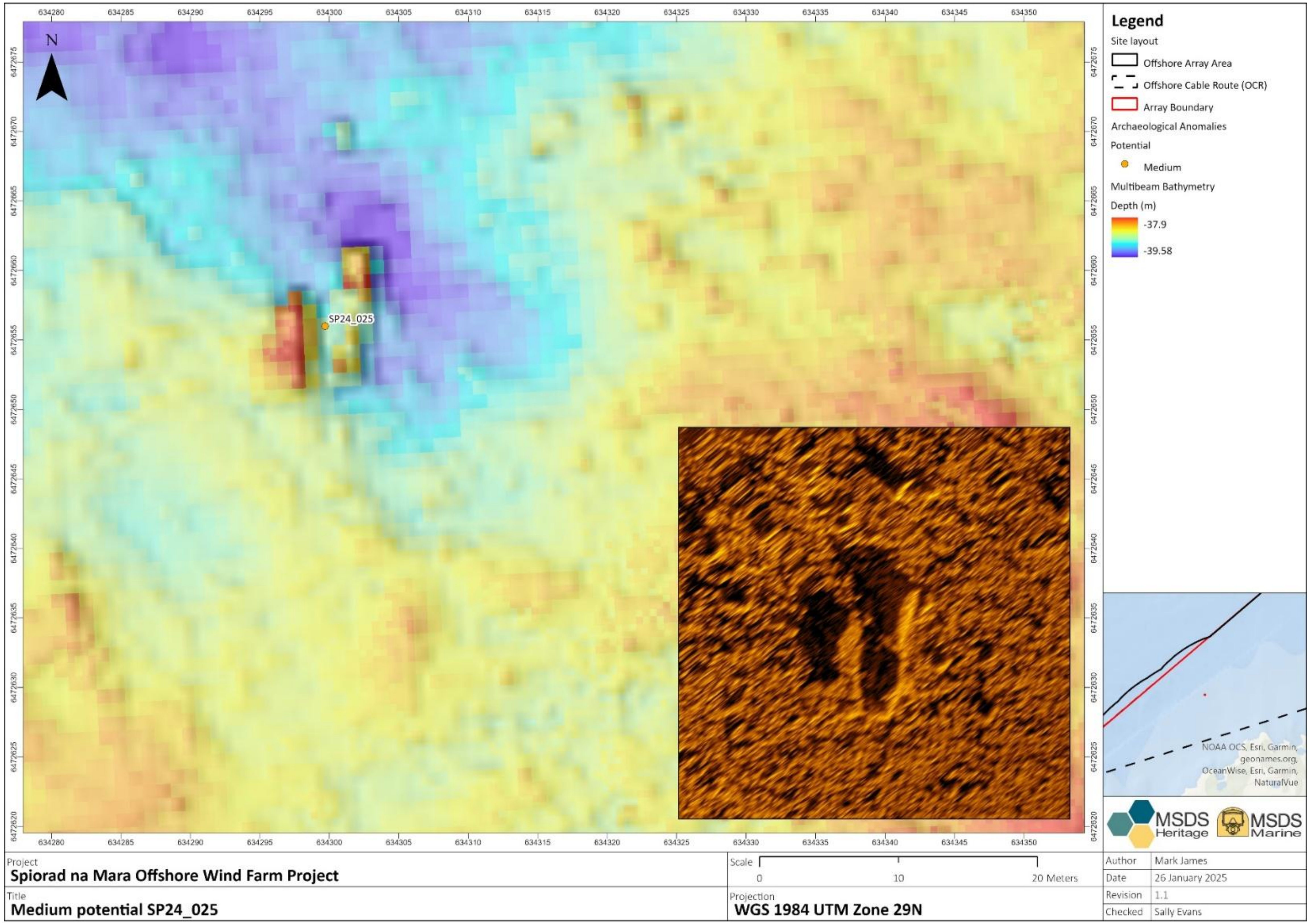

Plate 4-6 Medium potential SP24_025

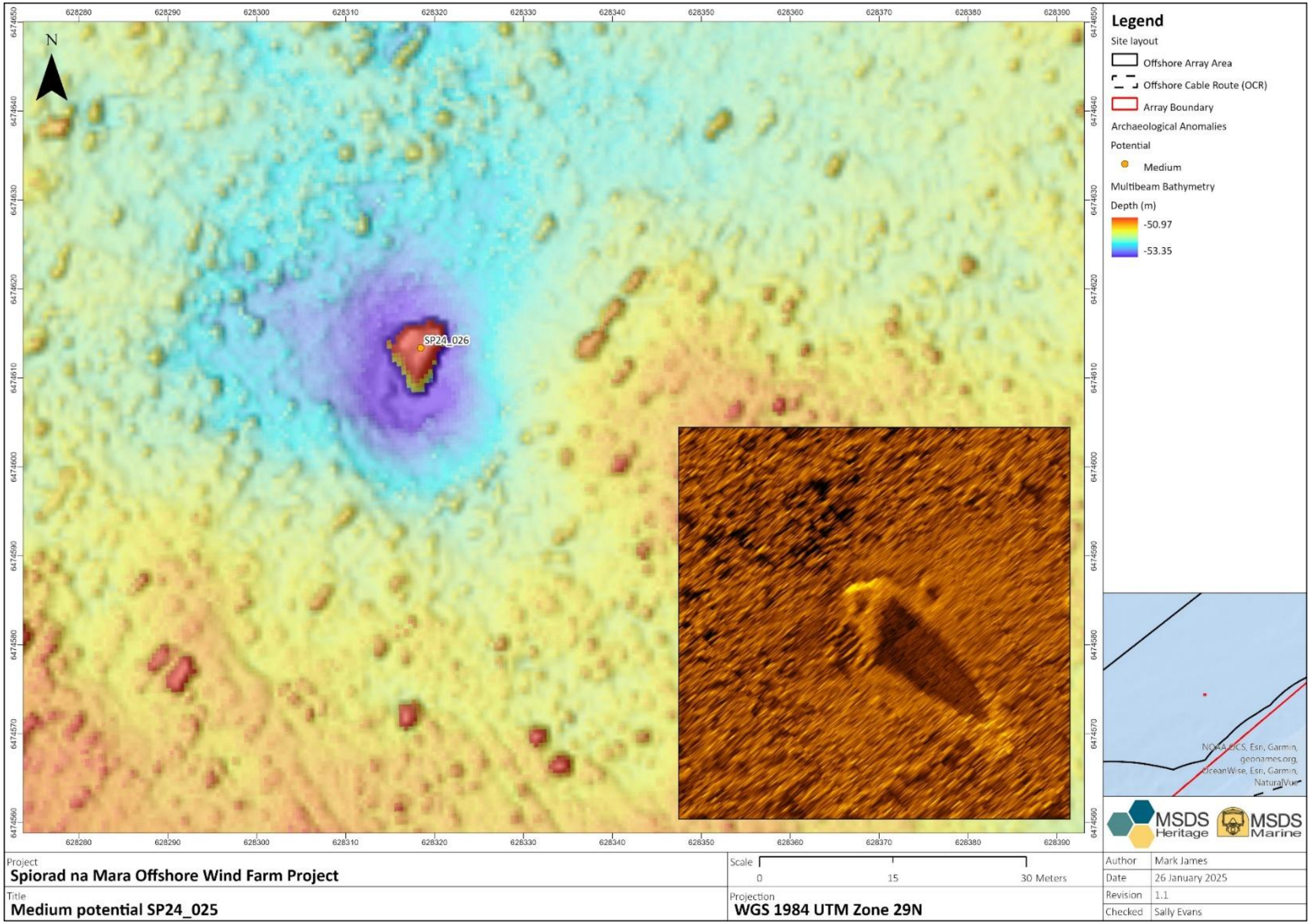

Plate 4-7 Medium potential SP24_026

4.4 HIGH POTENTIAL ANOMALIES

4.4.1.1 No anomalies interpreted as of high archaeological potential were identified within the geophysical survey data extents.

5 RESULTS OF MAGNETIC ANOMALIES

5.1 GEOLOGY

5.1.1.1 The underlying bedrock within the Offshore Project is comprised of 2 formations, Lewisian Gneiss predominantly in the southeast and covering most of the OCAS, and ironstained flowbanded Basalt to the northwest covering most of the Array Area (BGS, 1990). Both formations are igneous and have magnetic properties. There is a notable difference in the magnetic signature to the southeast and east of the Offshore Project (Lewisian Gneiss) and the northwest and west (Basalt) with the Basalt causing a generally higher, and denser variation. The outcropping bedrock appears generally to be comprised of Lewisian Gneiss. 2 basins were identified in the seismic data (Section 9), both towards the northeast of the Offshore Project, these basins correlate with areas where the effect of the underlying geology is reduced due to the increase in distance from the bedrock to the magnetometer.

5.1.1.2 As can be seen in **Plate 5-1**, the underlying igneous geology is visible in the data as linear striations of positive and negative changes in the magnetic field. These changes range from a few nT to thousands of nT. Whilst the variations are more prominent where the bedrock is Basalt (suggesting a stronger magnetic signature), it is still significant in areas where the bedrock is Lewisian Gneiss.

5.1.1.3 The underlying igneous geology has had a significant effect on the ability to undertake an archaeological assessment of the Magnetometer dataset with the overall distribution masking potential individual or discreet anomalies.

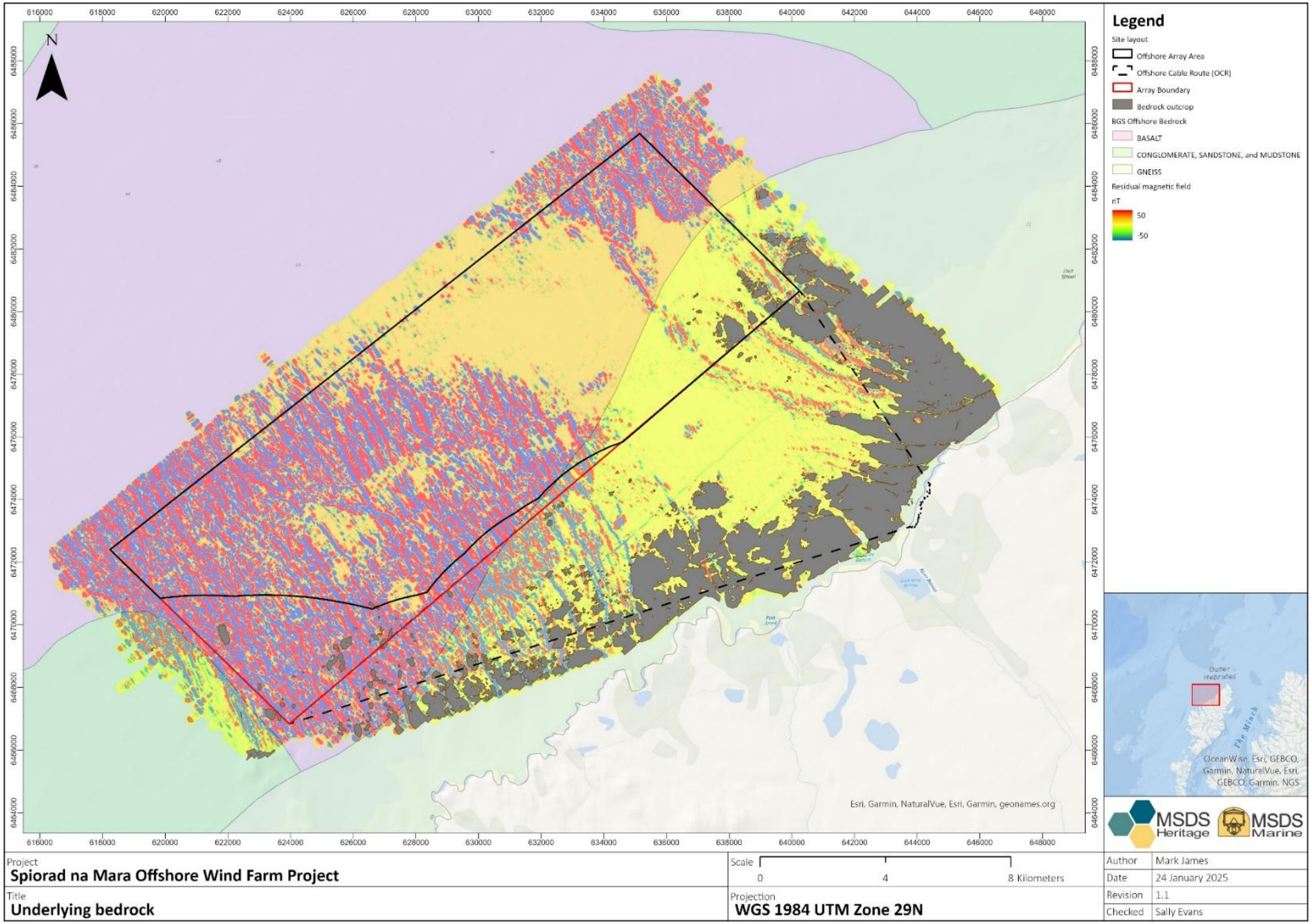

Plate 5-1 Underlying bedrock

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5.2 RESULTS

5.2.1.1 The archaeological assessment of magnetometer data typically aims to identify isolated anomalies of a ferrous mass that may indicate anthropogenic material of potential archaeological significance (calculated using the relationship of amplitude, aspect ratio, and distance from the sensor to the anomaly), or clusters of anomalies that could, for example, represent the remains of a wrecked vessel or aircraft.

5.2.1.2 Magnetic anomalies were picked within areas where the magnetic field was least affected by the underlying igneous geology, predominantly within the northeastern section of the Offshore Project. This resulted in the identification of 291 anomalies, 45 within the Array Area, 134 within the OCAS, and the remaining 112 within the wider extents of the data. To note, 169 of the identified anomalies lie within areas of exposed bedrock. The distribution of anomalies by amplitude is shown in **Table 5-1** with their spatial distribution presented in **Plate 5-2**.

Table 5-1 Magnetic anomalies by Amplitude (nT)

Amplitude (nT)	Array Area	OCAS	Data extents	Total
0 to 100	16	19	25	60
100 to 500	27	97	70	194
500+	2	18	17	37
Total	45	134	112	291

5.2.1.3 Anomalies identified within magnetometer data have a ferrous content and thus are generally anthropogenic in origin. However, in certain areas, such as surrounding the Offshore Project they can be associated with geological features. Magnetometer data differs from other data (such as SSS or MBES) in that there is no visual interpretation.

5.2.1.4 The magnetometer data collection methodology across the geophysical survey data extents was to run lines concurrently with the SSS and MBES, thus the line spacing is not sufficient for the detailed assessment of small, ferrous features on or below the seabed. The position for a magnetic anomaly can only be determined from directly below a single sensor, or where lines are run close enough together to be able to confidently position an anomaly seen on two, or more, lines. However, in combination with SSS and MBES data the magnetometer specification is considered sufficient to develop a broad understanding of the potential of the survey area, and to identify larger features of potential archaeological significance.

5.2.1.5 The positions of magnetic anomalies were viewed in the available datasets and where there was a strong correlation with a seabed anomaly, they were assessed for archaeological potential. All remaining anomalies have been included within this section.

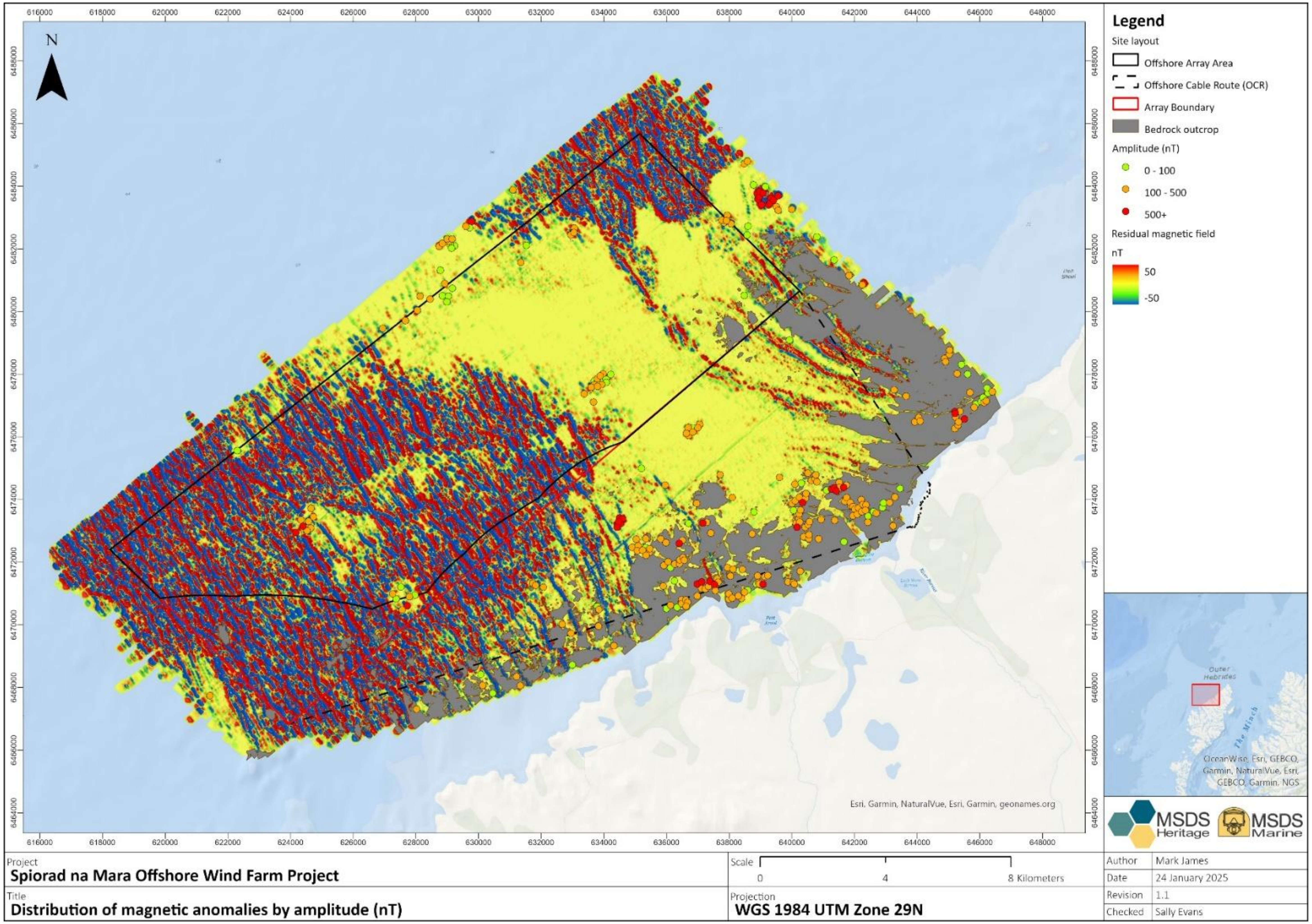

Plate 5-2 Distribution of Magnetic Anomalies by Amplitude (nT)

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5.3 CALCULATION OF MASS

5.3.1.1 The presentation, and categorisation, of magnetic anomalies by amplitude (nT) provides an effective way to gain a broad understanding of the distribution of ferrous material on, or just below, the seabed. However, to understand the data more comprehensively the ferrous mass needs to be calculated which is based on the amplitude and the distance from the magnetometer. However, with a line spacing of 100 m this is not possible to undertake accurately for anomalies that are not visible on the surface or visible on two lines of data, due to the potential distance of an anomaly from the magnetometer ranging from the altitude to the slant range of 50% of the line spacing (50 m range is equal to 51 m slant range at 10.0 m altitude).

5.3.1.2 Therefore, all calculations of mass are made using the assumption the anomaly lies directly below the magnetometer, with the distance used for the calculation being equal to the recorded altitude of the magnetometer. Furthermore, calculations are made assuming an anomaly ratio of 1:1. The distribution of anomalies by estimated mass is shown in **Table 5-2** with their spatial distribution presented in **Plate 5-3**.

Table 5-2 Magnetic anomalies by ferrous mass (kg)

Estimated Mass (ton)	Array Area	OCAS	Data extents	Total
0 to 5	18	29	38	85
5 to 25	25	89	59	173
25 +	2	16	15	33
Total	45	134	112	291

5.3.1.3 The presentation of mass in an area heavily influenced by the underlying geology is unlikely to provide results that are conducive for archaeological assessment. This can be noted with all of the anomalies being measured in tons, and not kilograms (kg). The distribution of the anomalies by estimated mass is broadly similar to the distribution by amplitude, however it provides a more robust basis for archaeological assessment.

5.3.1.4 Typically, and dependant on the survey specification and the distance from the target, isolated anomalies under 50 to 100 nT or 500 kg are considered to be of limited, or low, potential to be of archaeological significance.

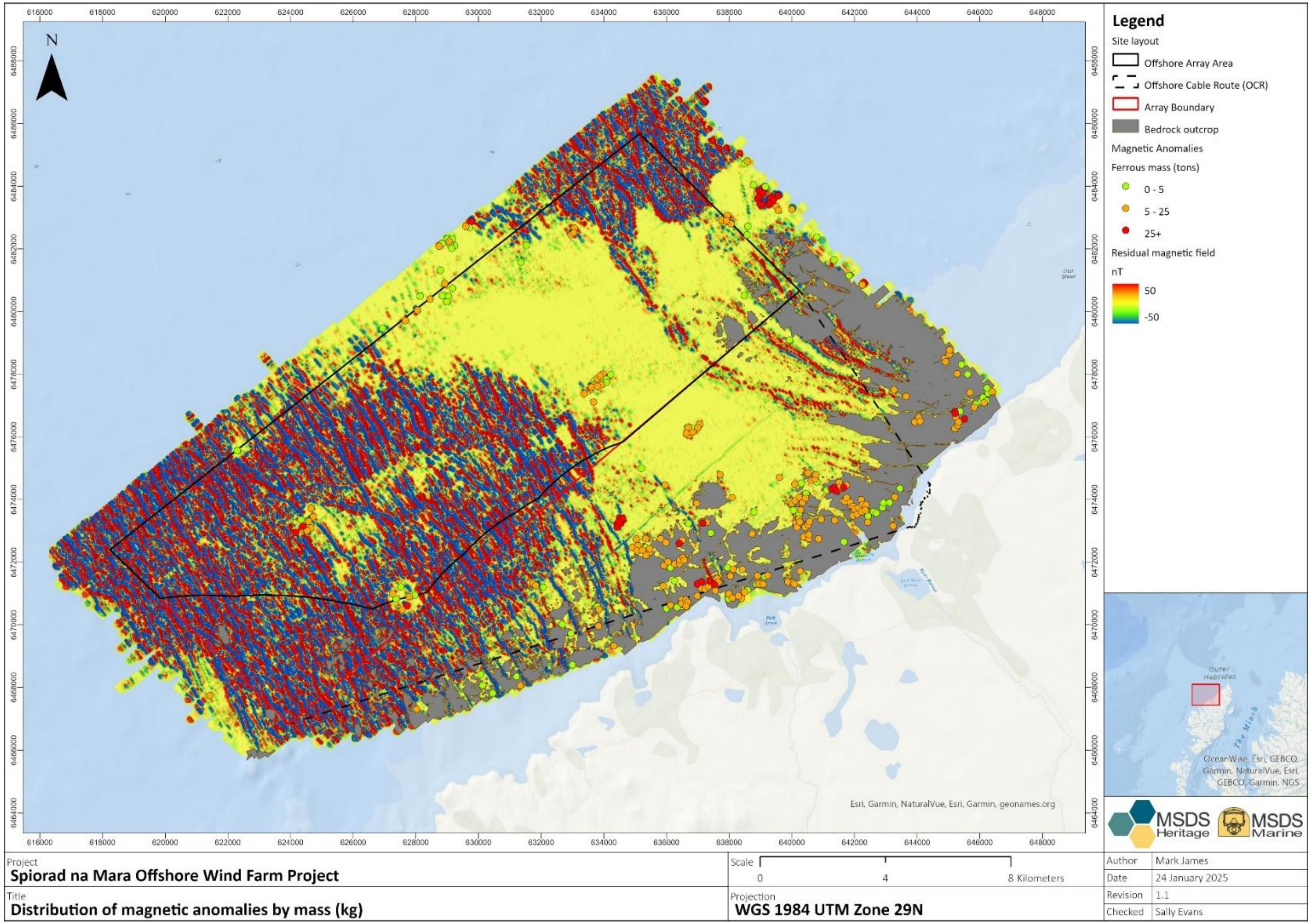

Plate 5-3 Distribution of magnetic anomalies by mass (kg)

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5.4 OVERVIEW OF MAGNETIC ANOMALY DISTRIBUTION AND INTERPRETATION

5.4.1.1 The distribution of magnetic anomalies across the Offshore Project is not uniform with anomalies primarily being identified within the areas less affected by the underlying geology. Over half (58%) of the anomalies are located in areas of exposed bedrock, generally to the southeast of the Offshore Project adjacent to the shoreline. The majority of the remaining anomalies are clustered in groups (indicating the same feature), many of which are over 500 m in diameter.

5.4.1.2 The positions, and surrounding areas, of all magnetic anomalies were viewed alongside the SSS and MBES data, both of which provide a visual representation of the seabed. None of the anomalies were able to be definitively correlated with features likely to represent anthropogenic material. 169 anomalies were located within areas of exposed bedrock, thus the potential for burial is very low, given the significant ferrous mass of the identified anomalies it is highly likely that if they represented anthropogenic material, it would be visible within the SSS or MBES data.

5.4.1.3 The anomalies were further assessed alongside the magnetometer Total Field and Residual grids. All have been interpreted as being highly likely to represent underlying geology. Whilst many anomalies record a lower variation in the magnetic field than within areas where the geology is more dominant, the linear form across the Offshore Project is consistent and can be traced between areas.

5.5 DISCUSSION OF POTENTIAL

5.5.1.1 All the magnetic anomalies identified within the Offshore Project have been interpreted as likely to be related to geological features or may potentially represent ferrous anthropogenic material that cannot be differentiated from the underlying geology.

5.5.1.2 In the areas of exposed bedrock, predominantly to the southeast and east of the OCAS, there is limited potential for ferrous anthropogenic material to be buried and thus not visible within the SSS or MBES data. However, there is some potential for material to be obscured within infilled gullies.

5.5.1.3 Across the remainder of the Offshore Project the sediment thickness is generally less than 2.0 m, with the notable exceptions being the basins identified in the seismic data and the area along the intersection of the Array Area and the OCAS, and southwestern areas of the Array Area and the OCAS (**Plate 5-4**). Where the sediment thickness is below 2.0 m this is likely to preclude the presence of large (and therefore potentially significant) anthropogenic features such as shipwrecks.

5.5.1.4 Whilst there is potential for large ferrous features of anthropogenic origin, and therefore of potential archaeological interest, to either be buried or obscured in the magnetometer data by the underlying geology, it is considered low across the majority of the Offshore Project. It would therefore not be proportional to assign potential, and therefore mitigation of avoidance, to anomalies that are likely to represent geological features.

5.5.1.5 There is a higher potential for smaller ferrous features, including not only material of archaeological interest but modern marine debris, to be present within the Offshore Project although not able to be identified within the magnetometer data and these must be considered within the recommendations for mitigation (Section 10).

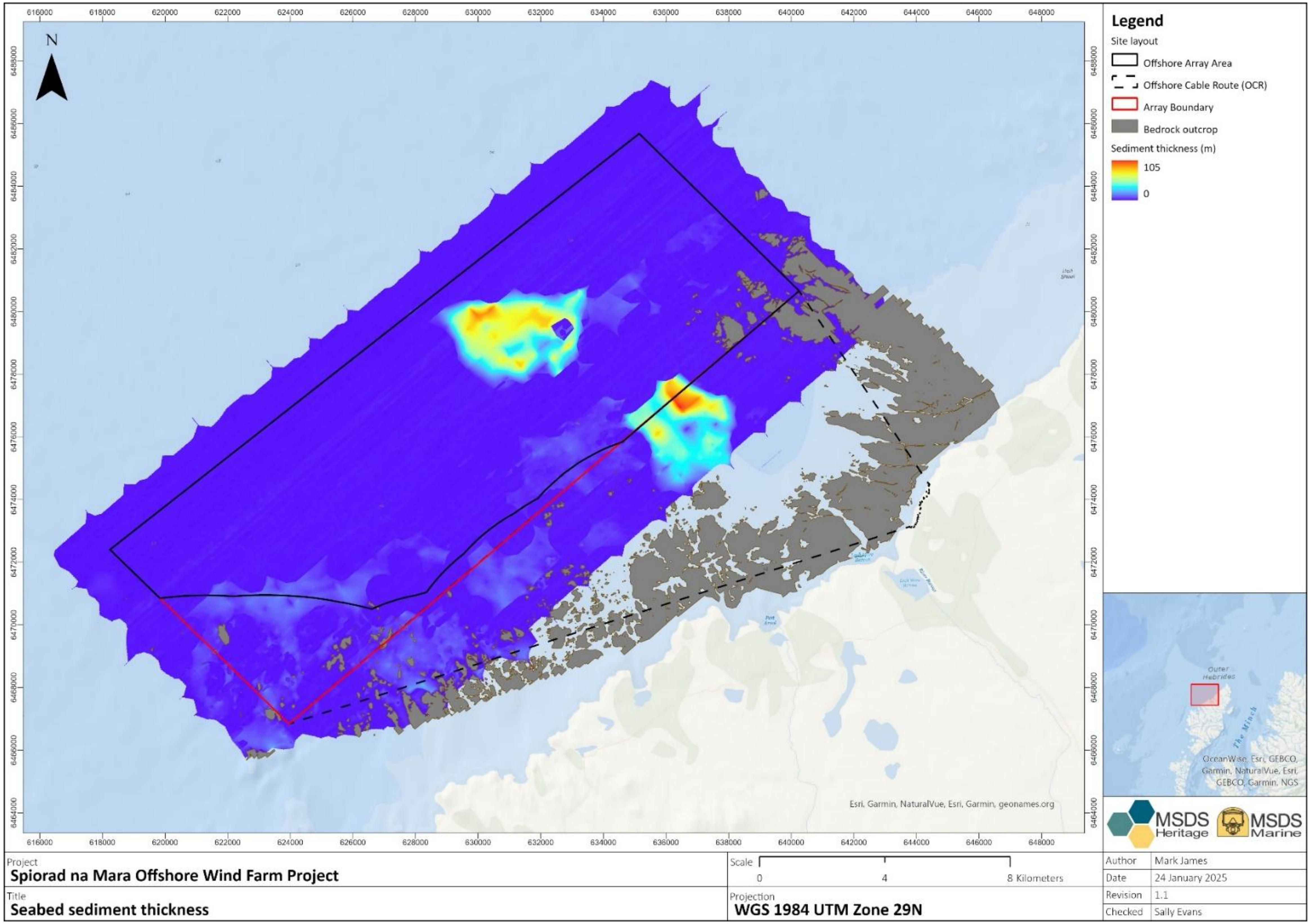

Plate 5-4 Seabed sediment thickness

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6 UNITED KINGDOM HYDROGRAPHIC OFFICE DATA

6.1.1.1 UKHO data from 2024 (most recent update 14 October 2024) were obtained for the extents of the geophysical survey data, and the Offshore Project, for correlation with anomalies identified within the geophysical data, and the establishment of TAEZs.

6.1.1.2 1 UKHO record was identified with the Array Area, 2 further records were identified outside of the Offshore Project but within 1.0 km of the geophysical survey data extents. Of the 3 records 1 is classed as *Dead* (not detected by repeated surveys, therefore considered not to exist) 1 as *Lifted* (a salvaged wreck), and 1 as *Live* (wreck considered to exist).

6.1.1.3 The categories of records, along with record counts (*dead* and *lifted* record counts in brackets), are detailed in **Table 6-1**, and the distribution presented in **Plate 6-1**.

Table 6-1 UKHO records by type within the geophysical survey data extents

Record Type	Array	OCAS	Data Extents	Total
Wreck	0 (0)	0 (0)	2 (1)	2 (1)
Foul Ground	1 (1)	0 (0)	0 (0)	1 (1)
Total	1 (1)	0 (0)	2 (1)	3 (2)

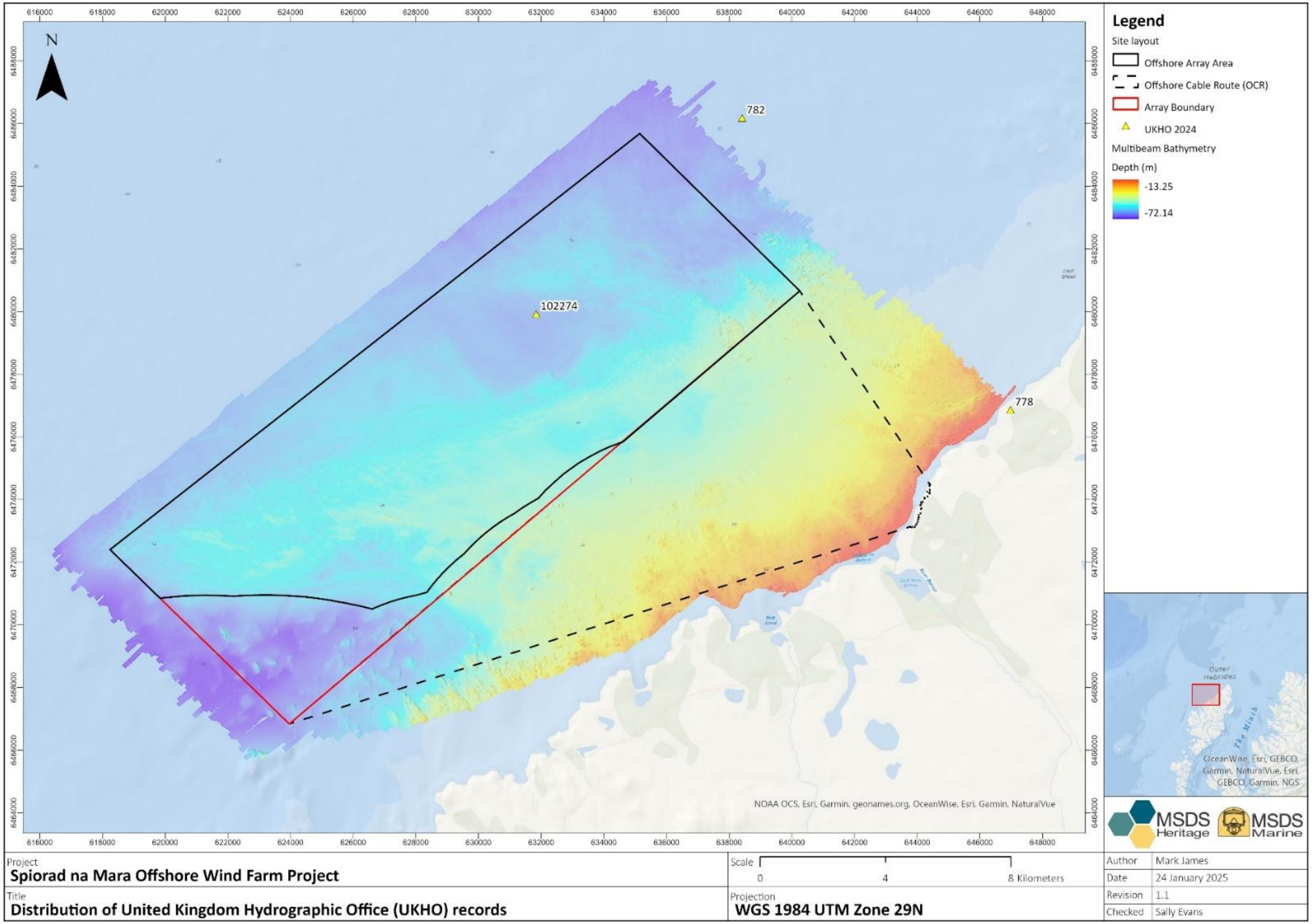

Plate 6-1 Distribution of United Kingdom Hydrographic Office (UKHO) Records

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6.2 UKHO RECORDS OF WRECK

6.2.1.1 Of the 3 UKHO records identified, 2 are records of wrecks. UKHO data typically, where known, lists information about the wreck, the circumstances of its loss, surveying details, and whether the record is considered *live* or dead. A *dead* record is one which has *not been detected by repeated surveys, therefore considered not to exist*(wrecksite.eu, 2025). Whilst the decision to amend a wreck to dead is based on data available from repeat surveys, records can be amended for a number of reasons including:

- Deterioration of the wreck to such a degree that it no longer exists on the seabed;
- Continual burial of the wreck so that the presence is not detected over repeat surveys;
- The identification of the wreck as a natural feature;
- Most commonly; the wreck not existing at the listed location due to inaccurate reporting or positioning at the period of identification.

6.2.1.2 The position of the UKHO records were reviewed in the data, where there was coverage, and an assessment made as to whether they were visible, or likely to exist on the seabed. The UKHO records relating to wreck are summarised in **Table 6-2** and a description of each wreck provided below.

Table 6-2 UKHO records of wreck within the geophysical survey data extents

Record	Status	Name	Date Sank	Date Recorded	Last Detected	Visible in Data
782	Live	Unknown	Unknown	1982	1982	Outside
778	Dead	*Borgin*	1980	1980	2019	Outside

6.2.2 UKHO RECORD 782

6.2.2.1 UKHO record 782 lies c. 2.7 km northeast of the northeastern boundary of the Array Area, and c. 1.0 km outside of the geophysical survey data coverage. The record relates to an unknown wreck first identified in 1982. The wreck is described as measuring 50 m x 25 m and standing 9.0 m proud of the seabed. No further information is recorded. The size, including the height, would suggest the remains of a steel wreck, and whilst inaccuracies in the positions of UKHO records, especially older ones, can occur it is highly unlikely that the remains of the wreck would be located within the Offshore Project.

6.2.3 UKHO RECORD 778

6.2.3.1 UKHO record 778 lies c. 3.5 km northeast of the eastern boundary of the OCAS, and c. 340 m outside of the geophysical data coverage. The record relates to the wreck of the *Borgin* a schooner driven ashore on rocks and abandoned on 2 December 1980. The wreck is recorded as being 124 tons, with a wooden hull. The wreck was recorded as a total loss. Given the nature of the wrecking event there is potential for the remains, or parts thereof, to have washed into the OCAS, however the seabed in the vicinity is not conducive to burial and therefore preservation, no remains were identified in the geophysical data. Whilst no information is provided about the construction date of the wreck by the UKHO, Canmore provide a date of 1943 (Section 7). The potential construction date, and the date of sinking, may indicate limited archaeological potential if it was identified within the Offshore Project.

6.3 UKHO RECORDS OF FOUL GROUND

6.3.1 UKHO RECORD 102274

6.3.1.1 UKHO record 102274 lies within the Array Area approximately 2.5 km southeast of the northwestern boundary, and within the extents of the geophysical data. The record relates a drill pipe left protruding 2.0 m above the seabed. The record was created following a report made on behalf of the Applicant on 7 September 2023. The drill pipe was located and removed on 27 November 2023 and the record was amended to *Lifted*. The location of the record was viewed in the geophysical survey data and no evidence of remaining anthropogenic material was identified.

7 CANMORE RECORDS

7.1.1.1 Canmore maritime data from 2024 were obtained for the extents of the geophysical survey data, and the Offshore Project including a 1.0 km buffer, for correlation with anomalies identified within the geophysical data, and the establishment of TAEZs.

7.1.1.2 14 Canmore records were identified, 1 within the OCAS (but outside the extents of the geophysical survey data), 7 within the extents of the geophysical survey data, 2 on the outer extents of the geophysical survey data, and 4 outside the extents of the geophysical survey data and outside the OCAS and Array Area.

7.1.1.3 It should be noted that many of the Canmore records are Named Locations (NLO). An NLO is an arbitrary position given when the exact location of a wrecking event is not known, or based on, for example, eye witness accounts. It is not unusual for a number of wrecks to be assigned to the same NLO.

7.1.1.4 Each record is detailed in **Table 7-1** and discussed below, the distribution presented in **Plate 7-1.**

Table 7-1 Canmore records of wreck within the geophysical survey data extents

Record	Name	Position	Built	Sunk	Type
102834	Unknown	Inaccurate	Unknown	Unknown	Steel?
217481	*Alexander & Mary*	Unlocated	Unknown	1816	Brig
217551	*Maju*	Inaccurate	1874	1874	Clipper
260521	*Standard*	Unlocated	1882	1875	Lugger
271317	*Pheonix*	Unlocated	1812	1821	Brigantine
295133	*Borgin*	Unlocated	1943	1980	Craft
296032	*Superb*	Unlocated	Unknown	1862	Craft
296034	*Rucking*	Unlocated	Unknown	1870	Craft
321432	*Borgin*	Known	1943*	1980	Schooner
328309	Unknown	Inaccurate	Unknown	1833	Craft
327166	Unknown	Inaccurate	Unknown	1862	Craft
327215	Unknown	Inaccurate	Unknown	1864	Craft
328418	Unknown	Inaccurate	Unknown	1809	Brigantine
327838	Unknown	Inaccurate	Unknown	1824	Craft

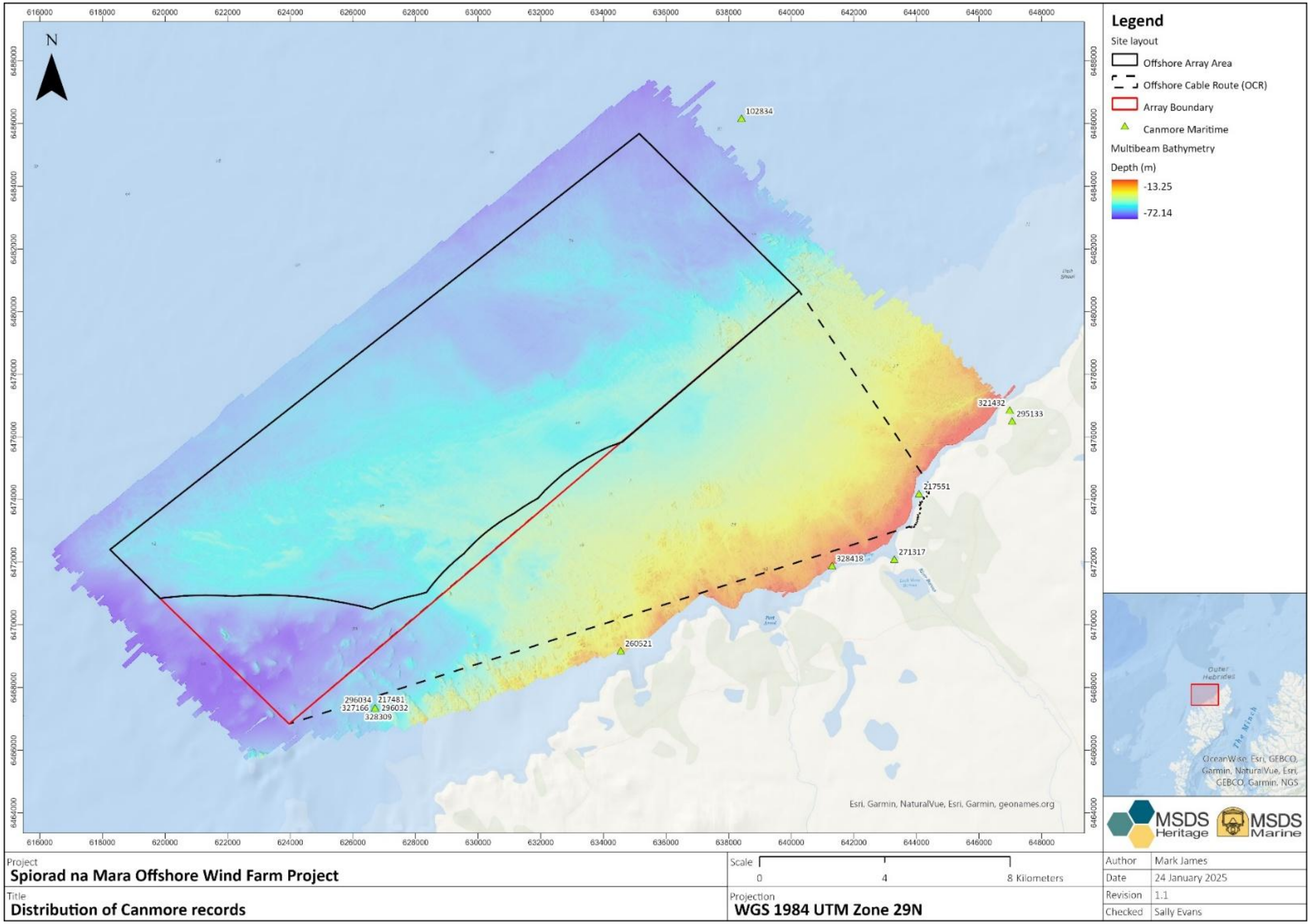

Plate 7-1 Distribution of Canmore records

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7.2 CANMORE RECORDS OF WRECK

7.2.1 CANMORE RECORD 102834

7.2.1.1 Canmore record 102834 originates from UKHO record 782 and is discussed in Section 6.

7.2.2 CANMORE RECORD 217481

7.2.2.1 Canmore record 217481 is located outside the OCAS, c. 330 m from the southern boundary, the record lies within the extents of the geophysical survey data. The record relates to the wreck of the *Alexander & Mary*, a brig enroute to Newcastle from Quebec when it was wrecked on the west side of Lewis in 1816, apparently stranded. The record notes the wreck as unlocated and no evidence was identified in the geophysical data. It is highly unlikely the wreck is present at the given location.

7.2.3 CANMORE RECORD 217551

7.2.3.1 Canmore record 217551 is located within the OCAS, c. 215 m from the eastern boundary, the record lies outside the extents of the geophysical survey data. The record relates to the wreck of the *Maju*, a clipper enroute to Rangoon from Dundee when it was wrecked on the west side of Lewis about a mile from the parish of Bacoas, in 1874. The *Maju* was not identified, but parts of the ship and a body were washed ashore at Aird Bharabais, and other locations along the coast. The record notes the parish of Bacoas is not identifiable on the available map evidence. It is highly unlikely the wreck is present at the given location.

7.2.4 CANMORE RECORD 260521

7.2.4.1 Canmore record 260521 is located outside the OCAS, c. 975 m from the southern boundary, the record lies within the extents of the geophysical survey data. The record relates to the wreck of the *Standard*, a lugger enroute to fishing grounds from Brue Barvas when it foundered off Shawbost/*Siabost* in 1882. The record notes the wreck as unlocated and no evidence was identified in the geophysical data. It is highly unlikely the wreck is present at the given location.

7.2.5 CANMORE RECORD 271317

7.2.5.1 Canmore record 271317 is located outside the OCAS, c. 0.9 m from the southern boundary, the record lies outside the extents of the geophysical survey data. The record relates to the wreck of the *Phoenix*, a Brigantine enroute to Belfast from Archangel when it was stranded in Bawas (Barvas/*Barabhas*) Bay in 1821. The cargo is recorded as being largely saved, but the *Phoenix* being totally wrecked. It is highly unlikely the wreck is present at the given location.

7.2.6 CANMORE RECORD 295133 AND 321432

7.2.6.1 Canmore records 295133 and 321432 relate to the wreck of the *Borgin,* the later of the 2 records originates from UKHO record 778 and is discussed in Section 6.

7.2.7 CANMORE RECORD 296032

7.2.7.1 Canmore record 296032 is located outside the OCAS, c. 330 m from the southern boundary, the record lies within the extents of the geophysical survey data. The record relates to the wreck of the *Superb*, no details of the wrecking are given, however cargo and wreckage were identified in 1862 in the approximate location. The record notes the wreck as unlocated and no evidence was identified in the geophysical data. It is highly unlikely the wreck is present at the given location.

7.2.8 CANMORE RECORD 296034

7.2.8.1 Canmore record 296034 is located outside the OCAS, c. 330 m from the southern boundary, the record lies within the extents of the geophysical survey data. The record relates to the wreck of the *Rucking*, no details of the wrecking are given, however cargo and wreckage were identified in 1862 in the approximate location, although cargo may also have washed ashore on Orkney/*Arcaibh*. The record notes the wreck as unlocated and no evidence was identified in the geophysical data. It is highly unlikely the wreck is present at the given location.

7.2.9 CANMORE RECORD 328309

7.2.9.1 Canmore record 328309 is located outside the OCAS, c. 330 m from the southern boundary, the record lies within the extents of the geophysical survey data. The record relates to the wreckage of an unknown American vessel washed ashore on the west side of Lewis/*Eilean Leòdhais* in 1833, no further information is given. No evidence was identified in the geophysical data, and it is highly unlikely the wreck is present at the given location.

7.2.10 CANMORE RECORD 327166

7.2.10.1 Canmore record 327166 is located outside the OCAS, c. 330 m from the southern boundary, the record lies within the extents of the geophysical survey data. The record relates to an unknown 3 masted vessel seen adrift off the west side of Lewis/*Eilean Leòdhais* in 1833, no further information is given. No evidence was identified in the geophysical data, and it is highly unlikely the wreck is present at the given location.

7.2.11 CANMORE RECORD 327215

7.2.11.1 Canmore record 327215 is located outside the OCAS, c. 330 m from the southern boundary, the record lies within the extents of the geophysical survey data. The record relates to wreckage and timber on the west side of Lewis/*Eilean Leòdhais* in 1864, no further information is given. No evidence was identified in the geophysical data, and it is highly unlikely the wreck is present at the given location.

7.2.12 CANMORE RECORD 328418

7.2.12.1 Canmore record 328418 is located outside the OCAS, c. 425 m from the southern boundary, the record lies within the extents of the geophysical survey data. The record relates to an unknown Danish brigantine being stranded from anchor in Barvas/*Barabhas* Bay in 1809, no further information is given. No evidence was identified in the geophysical data, and it is highly unlikely the wreck is present at the given location.

7.2.13 CANMORE RECORD 327838

7.2.13.1 Canmore record 327838 is located outside the OCAS, c. 330 m from the southern boundary, the record lies within the extents of the geophysical survey data. The record relates to cargo (pine logs) and wreckage on the west side of Lewis/*Eilean Leòdhais* in 1824, no further information is given. No evidence was identified in the geophysical data, and it is highly unlikely the wreck is present at the given location.

7.3 CANMORE POTENTIAL

7.3.1.1 With the exception of Canmore record 102834 (large wreck, identified by the UKHO), all the records are considered unlikely to represent wreck, or wreck material, at the given locations. Where the locations were within the extents of the geophysical data no evidence of anthropogenic material was identified. However, the presence of records relating to both wrecking events and reports of washed up cargo, highlight the potential for such remains to be present within the Offshore Project.

8 HISTORIC ENVIRONMENT RECORDS

8.1.1.1 Data from the Western Isles HER were provided by WSP for the extents of the geophysical survey data, and Offshore Project including a 1.0 km buffer, for correlation with anomalies identified within the geophysical data, and the establishment of TAEZs.

8.1.1.2 16 HER records were identified, all of which lie outside the OCAS, and outside the extents of the geophysical survey data. The records are all NLO's, with the positions being described as 'arbitrary'. All records are contained within an area 142 m x 80 m which lies c. 1.0 km from the southern boundary.

8.1.1.3 Each record is detailed in **Table 8-1** and discussed below, the distribution presented in **Plate 8-1**.

Table 8-1 Historic Environment Records of wreck within the geophysical survey data extents

Record	Name	Position	Built	Sunk	Type
MWE147513	*Clan Macquarrie*	Unlocated	Unknown	Unknown	Unknown
MWE147687	*Speedwell*	Unlocated	Unknown	1540-1900	Unknown
MWE147690	*Ann*	Unlocated	Unknown	1540-1900	Unknown
MWE147692	*Ann And Francis*	Unlocated	Unknown	1540-1900	Unknown
MWE147693	*Brayton*	Unlocated	Unknown	1540-1900	Unknown
MWE147694	*Unicorn*	Unlocated	Unknown	1540-1900	Unknown
MWE147699	*Hanna*	Unlocated	Unknown	1795	Brigantine
MWE147700	*Mary*	Unlocated	Unknown	1540-1900	Unknown
MWE147702	*Mariner*	Unlocated	Unknown	1796	Unknown
MWE147703	*Llandovery*	Unlocated	Unknown	1798*	Unknown
MWE147704	*Flora*	Unlocated	Unknown	1266-1860	Unknown
MWE147705	*Favourite*	Unlocated	Unknown	1880*	Unknown
MWE147706	*Union*	Unlocated	Unknown	1811	Unknown
MWE147707	*Sally*	Unlocated	Unknown	1801	Unknown
MWE147708	*Medea*	Unlocated	1794	1811	Unknown
MWE147719	*Alexander And Mary*	Unlocated	Unknown	1816	Brig

* Date given is the date of the source, date of sinking not given

8.2 HISTORIC ENVIRONMENT RECORD POTENTIAL

8.2.1.1 All the records are considered unlikely to represent wreck, or wreck material, at the given locations. However, the presence of records relating to both wrecking events and reports of washed up cargo, highlight the potential for such remains to be present within the Offshore Project.

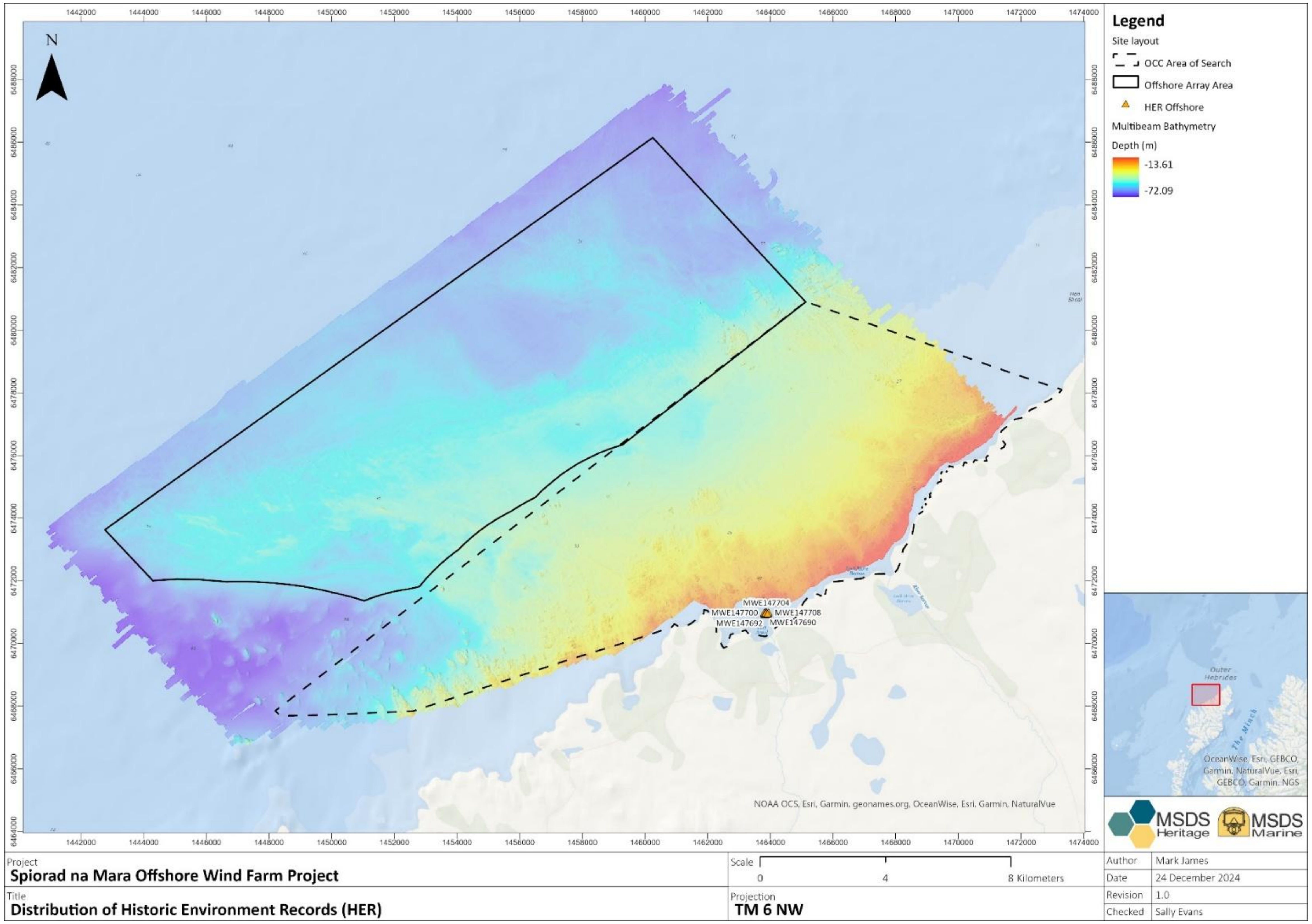

Plate 8-1 Distribution of Historic Environment Records

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9 PALAEOLANDSCAPE ASSESSMENT

9.1.1.1 This section provides a geological summary and assessment of the palaeoenvironmental and prehistoric archaeological potential of the Offshore Project, taking into account the depositional environment, date, nature, and post-depositional processes of the Quaternary sequence, which may have influenced this potential. Unit names follow those set out within the Aratellus interpretation report (Aratellus, 2024).

9.2 GEOMORPHOLOGY

9.2.1.1 Offshore Project has been subject to varied conditions during the Quaternary Period, with several erosive events that have affected the geomorphology of the area. Key features are:

- Platforms: Offshore Project lies upon the Hebrides Shelf, with the West Shetland Shelf further northeast. The Hebrides Shelf is characterised by metamorphic Lewisian, sedimentary Permo-Triassic and igneous Palaeogene geologies, characterised across Offshore Project by large areas of outcropping bedrock;
- Basins: Offshore Project is flanked by the Flannan Basin, to the southwest, and the North Lewis Basin, to the northeast. The West Flannan Basin lies further west and the West Lewis Basin further north. 2 narrow, deep basins are illustrated within the Array Area by the SBP and UHRS data, up to c. 110 m deep (**Plate 9-1**);
- Incised channels: the BGS illustrates a swathe of exposed bedrock within the Offshore Project, noting that the upper surface of this is "deeply eroded and filled incision[s]" (BGS, 2989). These incisions are minor, the SBP suggesting up to 9.0 m in depth. The channels cut into the bedrock are visible in **Plate 9-1**;
- Moraines: seabed moraines, evidence of former glaciers within the Offshore Project, are visible within the MBES data and have been mapped and interpreted by Bradwell *et al*, (2019 and 2021)(**Plate 9-1**);
- Boulders: extensive boulder fields have been identified across the Offshore Project, principally in association with sandy gravel seabed sediments.

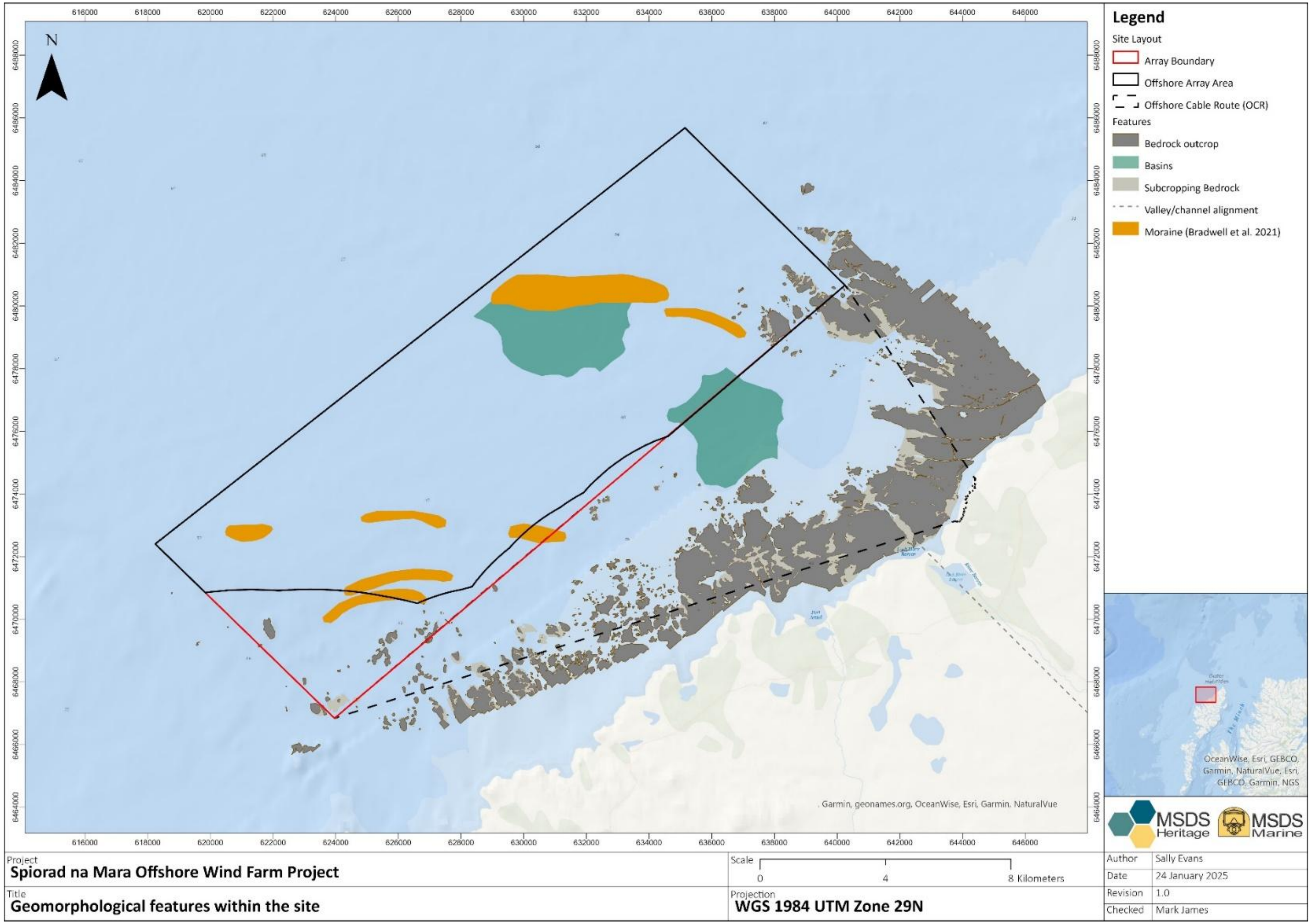

Plate 9-1 Geomorphological features within the Offshore Project

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9.3 THICKNESS OF QUATERNARY SEQUENCE

9.3.1.1 Following assessment of seismic data and the ground model, the thickness of the Quaternary sequence as mapped by Aratellus (2024) for the Array Area using the SBP and UHRS data is considered accurate. The MBES data provides information for the nearshore area (OCAS), in particular where exposed and subcropping bedrock indicate thin to no sediment cover. Sediment thickness in this area is also partially informed by the (limited) geotechnical work, with mapping from the seismic data not undertaken due to poor data quality.

9.3.1.2 These sources indicate that the depth of sediment across the Offshore Project is variable. The MBES data demonstrate the presence of frequent outcropping and subcropping bedrock in the nearshore area, indicating limited Quaternary sediments in these areas (**Plate 9-2**). Bedrock at the surface was confirmed in cores 202 and 204, as expected based on the MBES data.

9.3.1.3 Gullies and depressions within the bedrock however do hold sediments in the nearshore area. Boreholes 205, 205a, 206 and 206a were taken from the nearshore area in areas where sediment is indicated by an absence of outcropping bedrock on the MBES. Unfortunately, no sediment was recovered in location 205 and 205a (the report notes that the drill string was deviating from vertical on borehole entry). However, at location 206a 0.35 m of gravel and cobbles were noted overlying the Gneiss bedrock. Core 102 and 102a also lie close to the bedrock exposures and were reported to have gravel sediments to 0.25 m (Aratellus, 2023), with core loss noted below. While the depth of sediment could not be reliably mapped in the nearshore area on the seismic data, the MBES data do show sediments lying within the depressions in this area.

9.3.1.4 For the offshore parts of the Offshore Project, the seismic data shows generally thin sediment cover, of less than 1.0 m thick in areas, extending to depths of *c.* 8.0 to 10.0 m. Core 103 and 103a lie in the southwest part of the Offshore Project, where this thinner sediment is noted. The cores recovered between 9.05 m and 4.8 m of Quaternary sediment, after which core loss is noted, and it is not clear whether bedrock was reached in either core.

9.3.1.5 The thickest areas of Quaternary sediment lie in 2 deep sediment basins, toward the east of the Offshore Project, within the Array Area and western part of the OCAS. 1 basin lies further offshore and 1 further inshore. Both are mapped within the offshore UHRS data. In these areas the seismic data demonstrates Quaternary deposits up to *c.* 105 m thick (**Plate 9-2**).

9.3.1.6 Borehole 101 and 101a were taken from the centre of the northerly basin, and 104 from its northern edge. Borehole 201 and 201a was taken from the southerly basin, on its southern edge. Borehole 101 achieved sporadic sample recovery to 3.37 m, recording a variety of Quaternary sediments, after which core loss was recorded and with the borehole ended at

6.84 m. Borehole 101a also recorded sporadic sample recovery of a variety of Quaternary sediments to 9.28 m at which point the borehole ended.

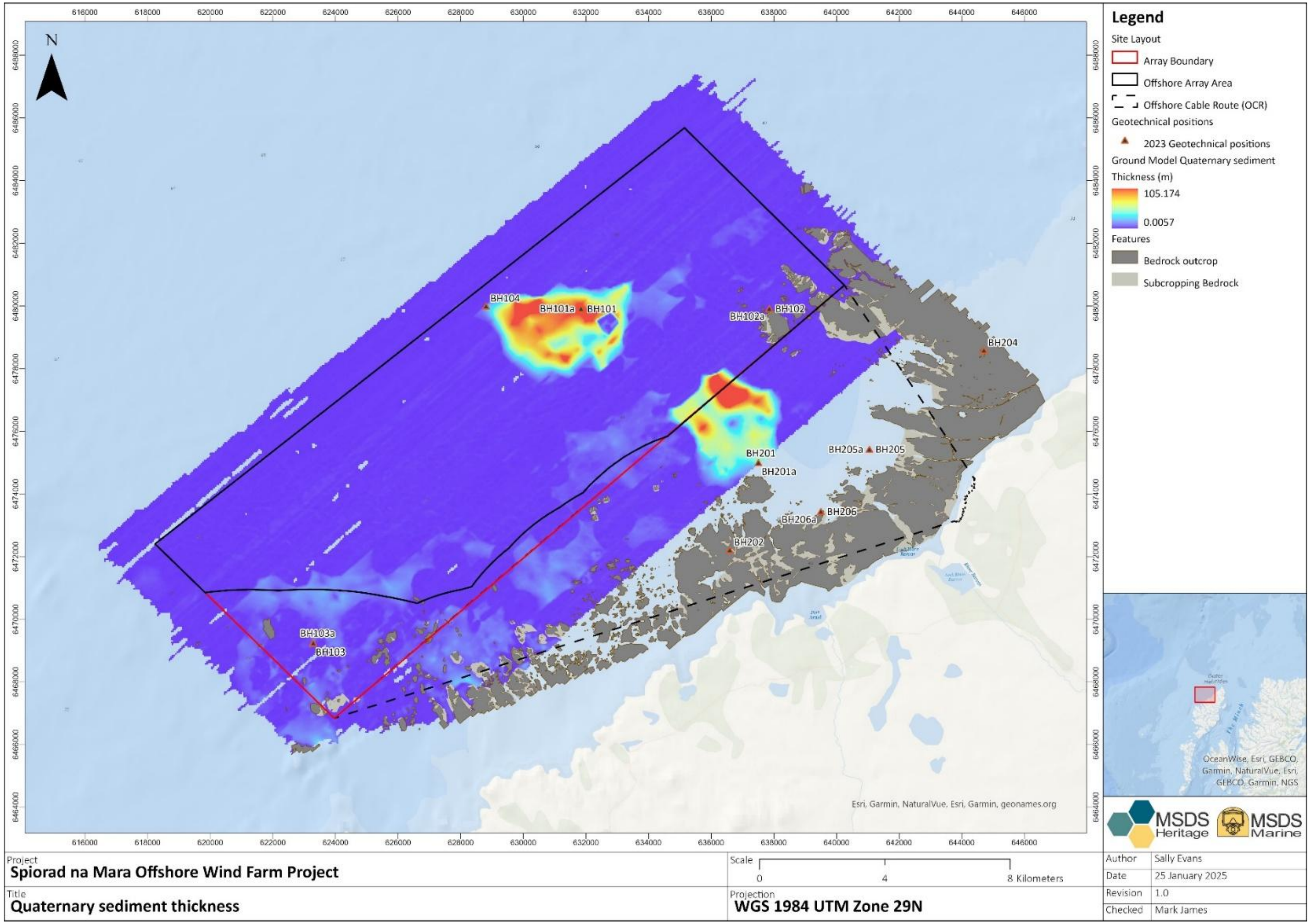

Plate 9-2 Quaternary sediment thickness

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9.3.1.7 Borehole 104 recorded sample recovery (of a variety of Quaternary sediments) to 10.59 m, after which core loss was recorded and the borehole ended at 12.53 m. Borehole 201 recovered no material, however 201a extended to a depth of 5.75 m. None of the boreholes therefore reached the base of the sediments within the northerly or southerly basins.

9.3.1.8 Although the BGS ORR does not hold isopach data for the Offshore Project specifically, regionally mapped deposits indicate a general thickness of Quaternary deposits. The 1: 250,000 Series Quaternary Geology map of Lewis/*Eilean Leòdhais* (BGS, 1989a)notes that the majority of the Offshore Project is mapped as undifferentiated Quaternary owing to the thin sediment cover within, with The Offshore Project falling partially within an area where sediments are thought to be less than 10.0 m in thickness, correlating with the findings of the Aratellus seismic survey (Aratellus, 2024). This map also notes the presence of the northernmost basin.

9.4 QUATERNARY SEQUENCE

9.4.1.1 Aratellus (2024) have interpreted the seismic data based on analysis of the SBP and UHRS data. These interpretations are set out within **Table 9-1** and **Table 9-2**, respectively. The data from the UHRS and SBP was not correlated and as such interpretations from both the UHRS and SBP are presented and are provisional at present. Geotechnical investigations are required to confirm the interpretations. These investigations will take place as part of the Offshore Project investigations programme associated with the pre-construction surveys for the Offshore Project. 1 geotechnical campaign has taken place, and the boreholes have been subject to geoarchaeological assessment (Stage 1)(Northland Power, 2024), however the geotechnical campaign itself (and therefore geoarchaeological information obtained) was limited by poor recovery of samples (Aratellus, 2023).

Table 9-1 Units identified within the SBP data of the Offshore Project by Aratellus

Unit	Horizon	Seismic Character	Expected Lithology
U05	H05	Low amplitude reflectivity.	Rock
U10	H10	Transparent reflectivity.	Gravelly sand and sandy gravel
U15	H15	Medium amplitude chaotic reflectivity, sometimes with strong amplitude boundary to underlying unit.	Sand and gravel
U17	H17	Low reflectivity.	Silt
U20	H20	Strong laminated reflectivity.	Sand and silts
U30 Bedrock	H30	Low reflectivity and low amplitude chaotic reflectivity.	Metamorphic/igneous rock. Regionally Lewisian gneiss/locally basalt

Table 9-2 Units identified within the UHRS data of the Offshore Project by Aratellus with interpretation by MSDS Marine

Unit	Horizon	Seismic Character	Interpreted Formation
H1	H1	Very shallow top layer, primarily concentrated in the southern and central regions of the survey area.	Seabed
H3	H3	Two deep, narrow basins in the central area of the Offshore Project. Cutting through H4. Well-layered infill. Onlapping or drape configuration.	Annie Formation
H4	H4	Present in the central and western parts of the Offshore Project, removed by basins H3.	Undifferentiated Quaternary deposits

9.4.1.2 Archaeological review of the ground model, Aratellus reports and a selection of seismic lines (including all nearshore SBP and UHRS data and a selection of offshore data) demonstrated that although Aratellus have identified a number of horizons across the Offshore Project, consistent differentiation of horizons within the Quaternary sequence across the Offshore Project was problematic in some areas, owing to data quality. The northeast part of the Offshore Project and both deep sediment basins were considered to have the best quality of data, and, within these areas, multiple horizons could be identified (see **Plate 9-3** for example). However, the southwest part of the Offshore Project exhibited poorer data quality and correlation was more difficult.

9.4.1.3 In general, it is considered that the identifications of horizons in the northeast part of the Offshore Project and the sediment basins are likely accurate, with those in the southwest less certain.

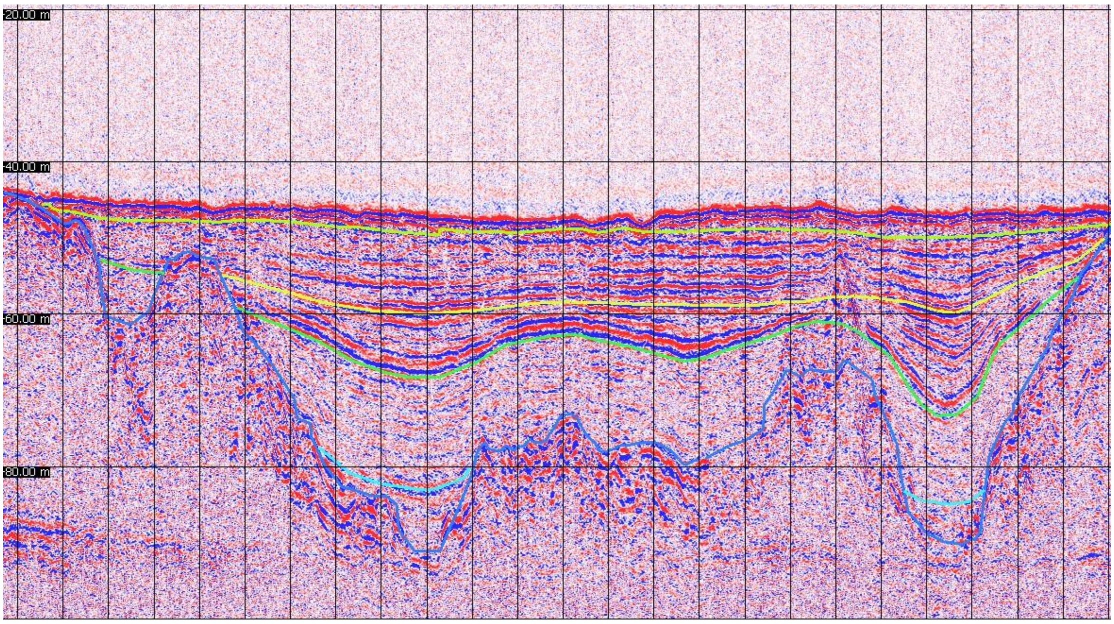

Plate 9-3 Example of data showing the south-eastern basin with multiple horizons present (line 15_009_UHRS0119_Final_Stack_Time.sgy)

9.5 PRE-QUATERNARY BEDROCK

9.5.1.1 Bedrock (Unit U30) has been identified across the Offshore Project, in many places outcropping or exhibiting a thin cover of seabed sediments, though deeper where the 2 basins lie (**Plate 9-2**). The bedrock is understood to comprise solid metamorphic (Lewisian gneiss) and igneous rock. The base of the bedrock was not identified, and the unit can only be characterised within the Offshore Project as outcropping or subcropping. Boulder fields across the outcrops contribute to the difficulty in penetration and resolution of the seismic data.

9.5.1.2 The BGS maps 2 principal bedrock types within the Offshore Project: undifferentiated, metamorphic Lewisian rocks across the OCAS and east/southeast parts of the Array Area; and Palaeogene igneous rock throughout the remainder of the Array Area (BGS, 1990).

9.6 QUATERNARY DEPOSITS

9.6.1 SUB-BOTTOM PROFILER UNITS

Unit 20

9.6.1.1 Unit U20 is defined by the irregular reflector H20 and is characterised by well-bedded, sub-parallel reflectors, widespread across the Offshore Project. It is believed to comprise layered sand and gravel, with areas of finer sediment. Horizon H20 is characterised by an erosional upper surface of the bedrock, defining the transition from solid rock to Quaternary sediment. It is recorded in the southwest, northeast and central parts of the Offshore Project, including in the area where the deep basins are present (**Plate 9-4**). As discussed above, the distribution of sediments in the southwest is not considered reliable due to poor data quality.

9.6.1.2 Although not correlated with a formation or member, the unit is interpreted as a product of a cycle of sea level fluctuations, defining a shift from finer to coarser sediment deposits and related to local depositional centres within the underlying bedrock.

Unit U17

9.6.1.3 Unit U17 overlies Unit U20, though is more limited in its distribution, included within the southwest part of area of data coverage, and over the area of the deep basins (**Plate 9-5**). The former positions now lie beyond Offshore Project and are considered unreliable. The unit is characterised by intermittent, chaotic reflectors and its basal horizon, H17, is indicative of a truncated erosional surface. The former feature is indicative of a gravel and sand composition, whilst the latter feature is suggestive of a high energy depositional environment. The sporadic occurrence of Unit U17 is suggestive of an infill of channels cut into the underlying bedrock.

Unit U15

9.6.1.4 Unit U15 is delineated by the continuous horizon H15 and characterised by its transparent reflectivity, with occasional internal reflectors. The unit likely comprises gravelly sand and sandy gravel. Distribution of Unit U15 is irregular expressing concentrations in the southwest and over the southernmost of the two basins (**Plate 9-6**). Only the latter is considered to be reliably mapped, owing to data quality issues in the southwest. The southwest area in which this deposit has been mapped now also lies beyond the Offshore Project. The unit ranges in depth from 0.03 to 9.0 m below seabed.

Unit U10

9.6.1.5 Unit U10 is delineated by the semi-continuous horizon H10 and characterised by its low amplitude reflectivity, indicative of a thin sediment veneer. This unit ranges in depth from 0 to 13.5 m below seabed, mostly 0.5 to 3 m thick, and principally comprises sand. Unit U10 was identified across the Array Area and has been interpreted as the most recent seabed sediment deposit (**Plate 9-7**). As with other deposits, the data quality in the southwest places uncertainty on the mapping in this area.

Unit U05

9.6.1.6 Unit U05 is characterised by low amplitude reflectivity, sparsely detected within the data, and is now primarily situated beyond the Offshore Project, in the southwest, though a small area in northeast parts of the Array Area has been reported (**Plate 9-8**). With depths of 0.11 to 25 m below seabed, this unit is interpreted as local rock formations.

9.6.2 UHRS UNITS

Unit H4

9.6.2.1 Unit H4 has been identified in the central and western parts of the Offshore Project, except where incised in the centre of The Offshore Project by the 2 basins. As with other deposits, the data and interpretations within the southwest part of The Offshore Project are considered unreliable.

Unit H3

9.6.2.2 Unit H3 comprises the fill of 2 deep, narrow basins in the central area of the Offshore Project, incising Unit H4. Their fills are well-layered, with onlapping or drape configuration. Their distributions are shown by **Plate 9-4**, **Plate 9-5** and **Plate 9-6**.

Unit H1

9.6.2.3 Unit H1 is present primarily within the southwest and central parts of the Offshore Project. The unit is shallow and of restricted depth. As with other deposits with a southwest distribution, the interpretation is considered unreliable in that part of the data.

9.6.3 SUMMARY

9.6.3.1 While the assessment of some of the data, particularly in the southwest, is considered unreliable, the data does demonstrate multiple horizons within the Offshore Project with the northeast area and the deep basins being best represented within the data. The BGS data, sea level and history of glaciation in the area is considered further below, to aid archaeological assessment.

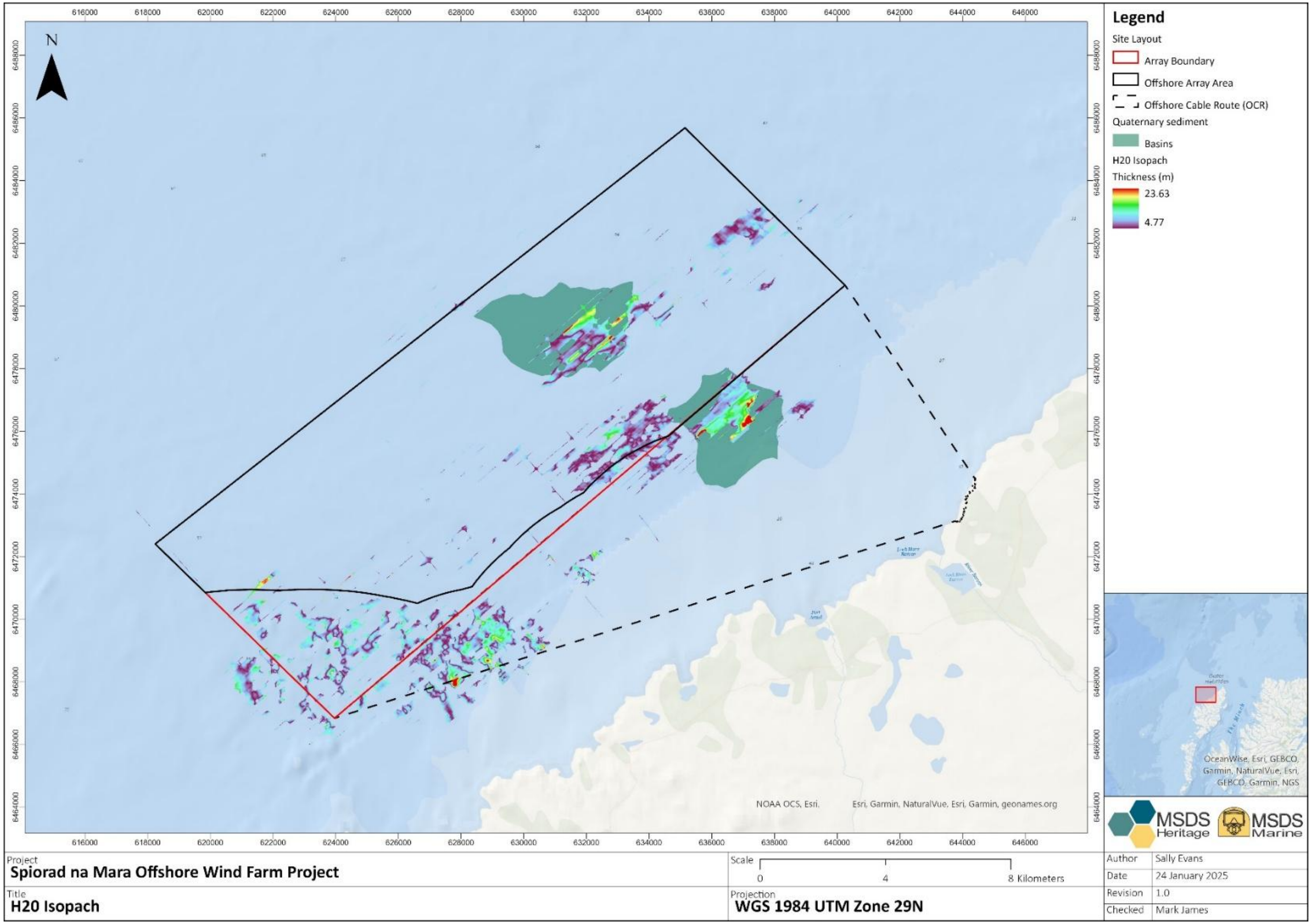

Plate 9-4 Horizon H20 Isopach

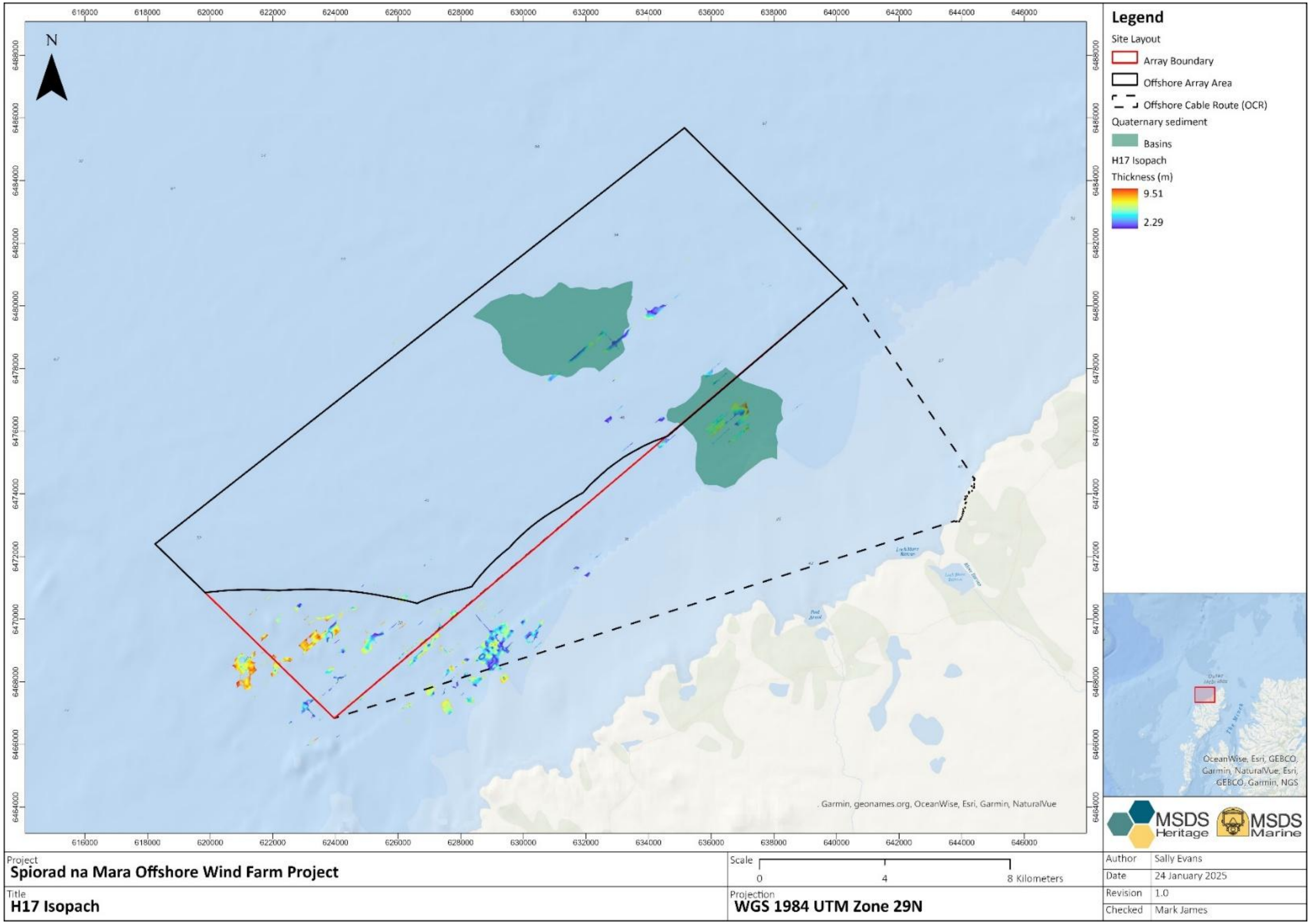

Plate 9-5 Horizon H17 Isopach

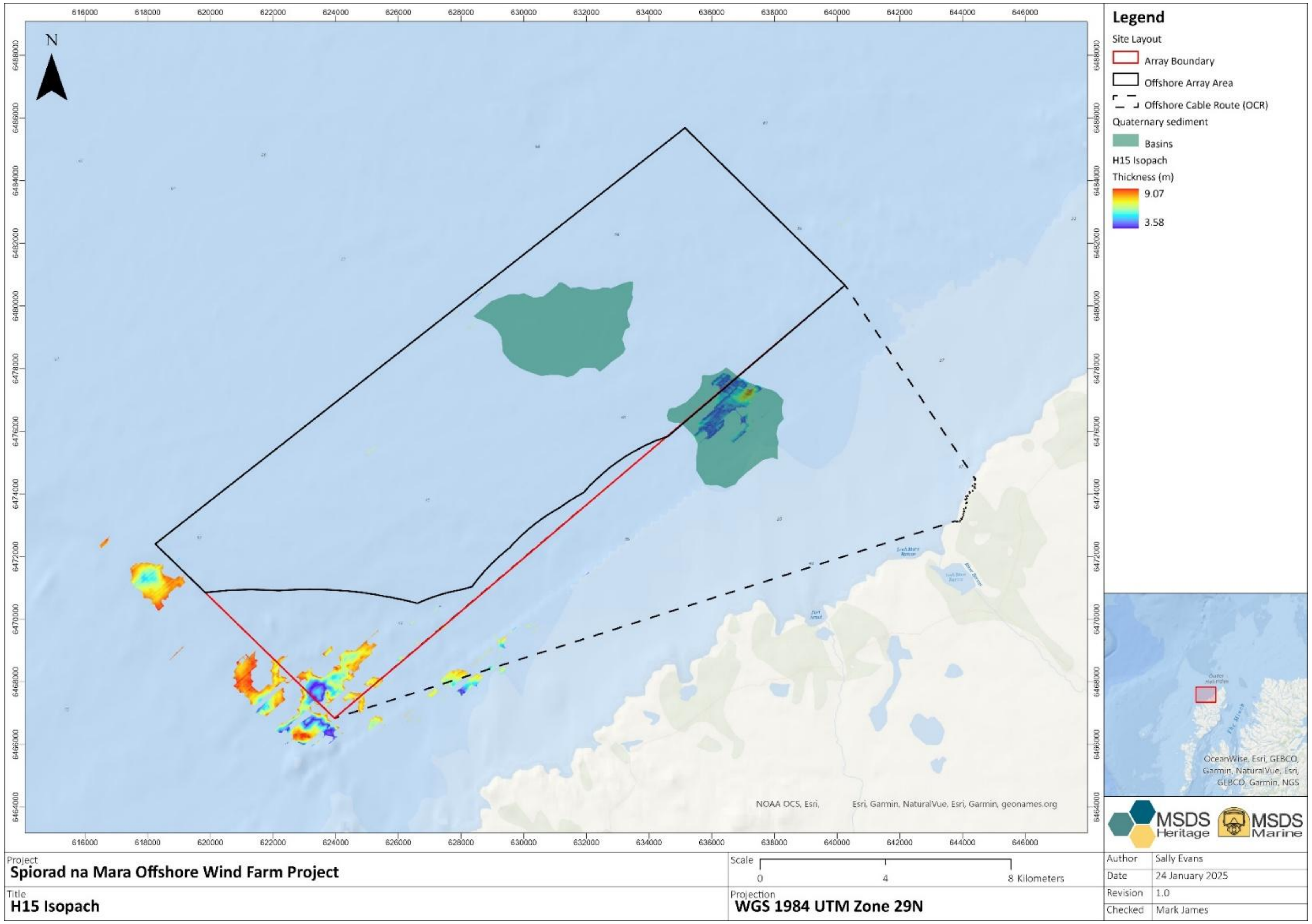

Plate 9-6 Horizon H15 Isopach

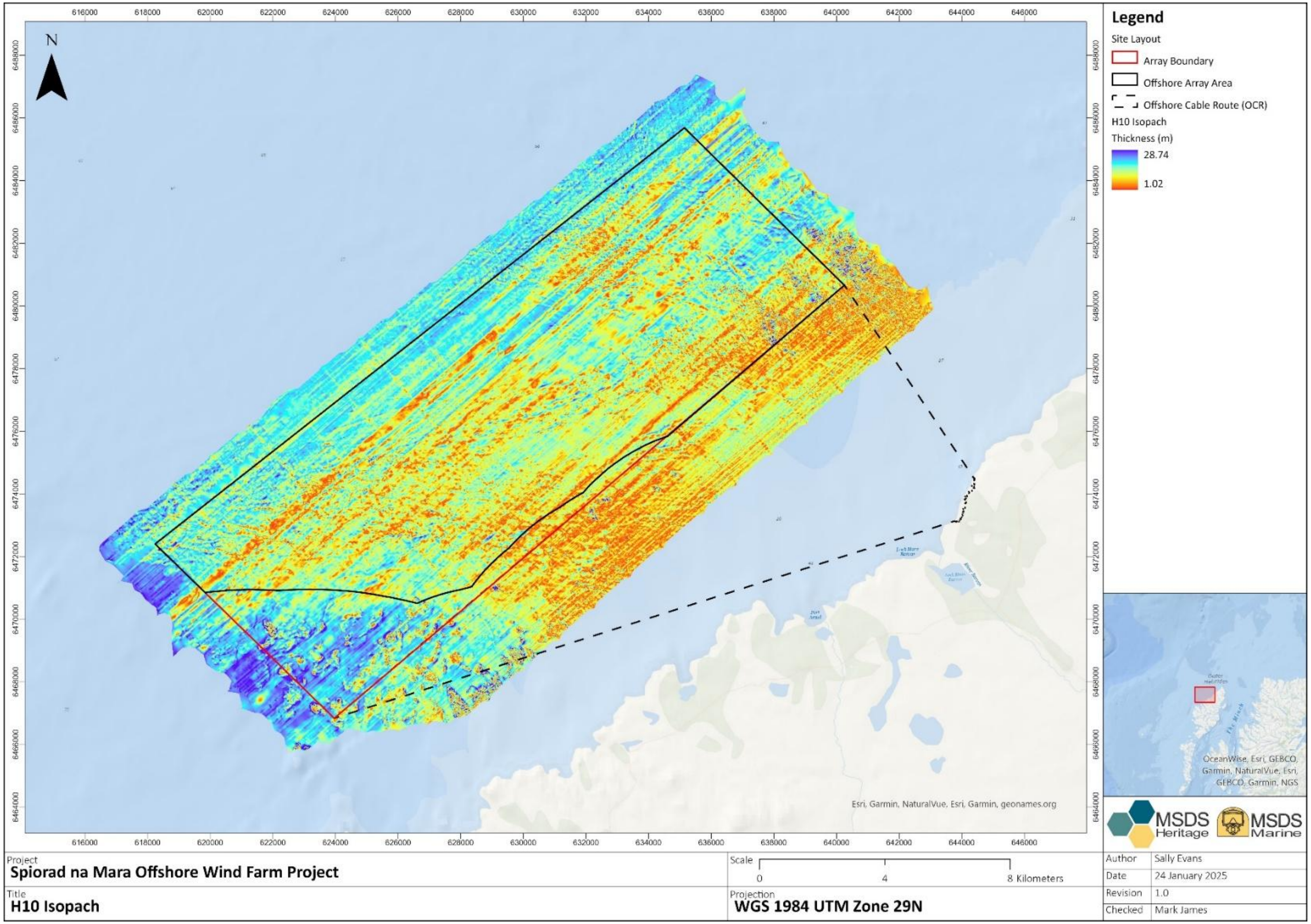

Plate 9-7 Horizon H10 Isopach

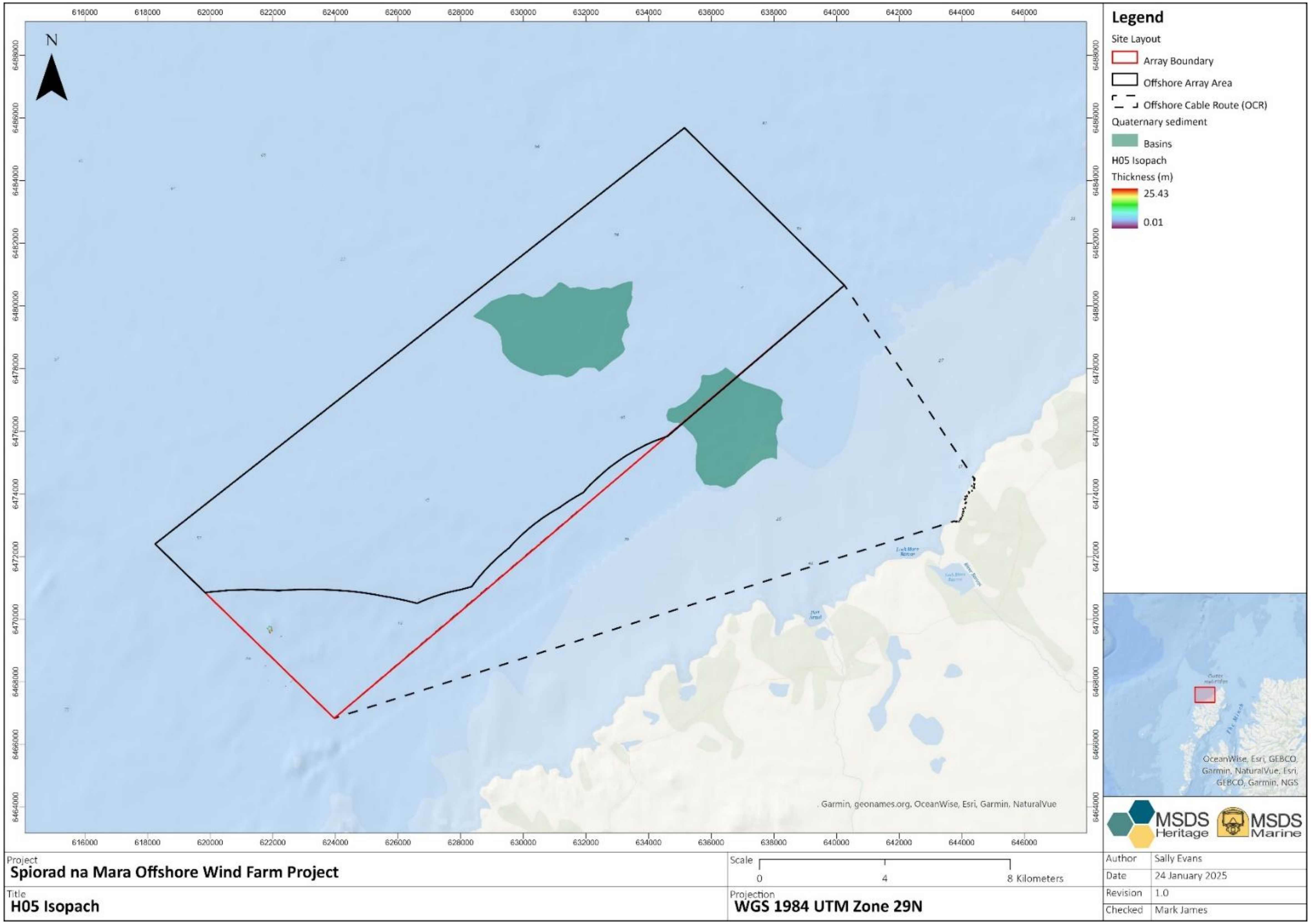

Plate 9-8 Horizon H05 Isopach

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9.7 QUATERNARY DEPOSITS: BGS OFFSHORE MAPPING

9.7.1.1 The geological sequence for the Offshore Project is illustrated by the BGS in terms of bedrock (BGS, 1990), Quaternary (BGS, 1989a) and seabed (BGS, 1989b) geologies. The principal part of the OCAS is excluded from the scope of the BGS mapping, although the seismic and MBES results indicate a predominance of outcropping bedrock in this sector.

9.7.1.2 Much of the Array Area is also characterised by outcropping bedrock by the BGS. However, where Quaternary deposits are mapped within the Offshore Project by the BGS they are defined as:

- Seabed sediments;
- The Annie Formation;
- Undifferentiated Quaternary deposits.

9.7.1.3 Seabed sediments are represented by SBP Unit 10 within the Offshore Project.

9.7.1.4 The Annie Formation is mapped by the BGS within the Array Area and correlates with the northern of the two deep basins identified in the UHRS data (**Plate 9-10**). The fill of both basins has been identified as Unit H3. The BGS mapping does not cover the area in which the other basin lies, however, other pockets of the Annie Formation are mapped further offshore by the BGS along the same northwest-southeast line as the 2 basins within the Offshore Project, indicating that the second basin is also likely to be filled by the Annie Formation (forming the most inshore of this line of basins). This is supported by the seismic characteristics of Unit H3 and the Annie Formation. Unit H3 has well-bedded reflectors with an onlapping or drape configuration. Likewise, the Annie Formation is described by the BGS as a *"Well-layered unit that infills localised hollows; variable onlapping to drape configuration. Reflectors truncated at sea bed, and locally obscured internally by gas blanking"* (Stoker and Bradwell, 2011). These deposits lie in an area which was characterised by good data, supporting the ability to positively interpret the data.

9.7.1.5 The Annie Formation has been identified in The Minch/*Mhaoil* and to the west of Lewis/*Eilean Leòdhais*, infilling localised hollows in the seabed. The Formation has been sampled in a deep hollow southeast of Stornoway/*Steòrnabhagh*, in The Minch/*Mhaoil*, and found to comprise soft silty clays (Stoker and Bradwell, 2011) representing well-layered, muddy, glaciomarine deposits of Late Devensian and Early Holocene date. Measuring up to 90 m deep, these deposits are encountered as the infill of Late Devensian erosional basins and hollows. Sampling (in particular in BGS borehole 78/4, collected *c.* 30 km southeast of the Offshore Project, off the east coast of Lewis/*Eilean Leòdhais*) shows that the uppermost sediments were indicative of an ameliorative depositional climate, with evidence for arctic conditions between 16-26 m (correlated with the Loch Lomond stadial), below which there was further evidence of amelioration, underlain by further evidence of cooling. This evidence has been interpreted as representative of the end of the Devensian glaciation, holding evidence of the Loch Lomond stadial, and then marking the recession of the ice sheets and climatic amelioration of the Holocene (Fyfe *et al*, 1993).

9.7.1.6 Boreholes within the Offshore Project were generally too shallow to provide detailed information on this deposit. Boreholes 101, 101a and 104 targeted the northern basin, while 201 and 201a targeted the southern edge of the southern basin. Borehole 101 collected sediments to 3.57 m, showing mainly sand and gravel sediments, and while borehole 101a extended slightly deeper, to 9.28 m, it showed the same pattern of sands and gravels. Borehole 104 recorded similar sediments to 10.59 m, though with some pockets of silt and clay (e.g. at between 9.29 to 9.79 m). Borehole 201a however, while only extending to 5.75 m, held evidence of gravels at the top, and sandy silts with multiple laminations of clay at depths of 2.95 to 4.30 m (location of this core and seismic profile for this location are shown by **Plate 9-9**). This may represent part of the Annie Formation, and the basal horizon of Unit H3 which marks this deposit does occur at shallow depths at the south side of the southern basin, supporting this interpretation. However, it is likely that the bulk of the Formation is represented at greater depths, as shown by **Plate 9-9**.

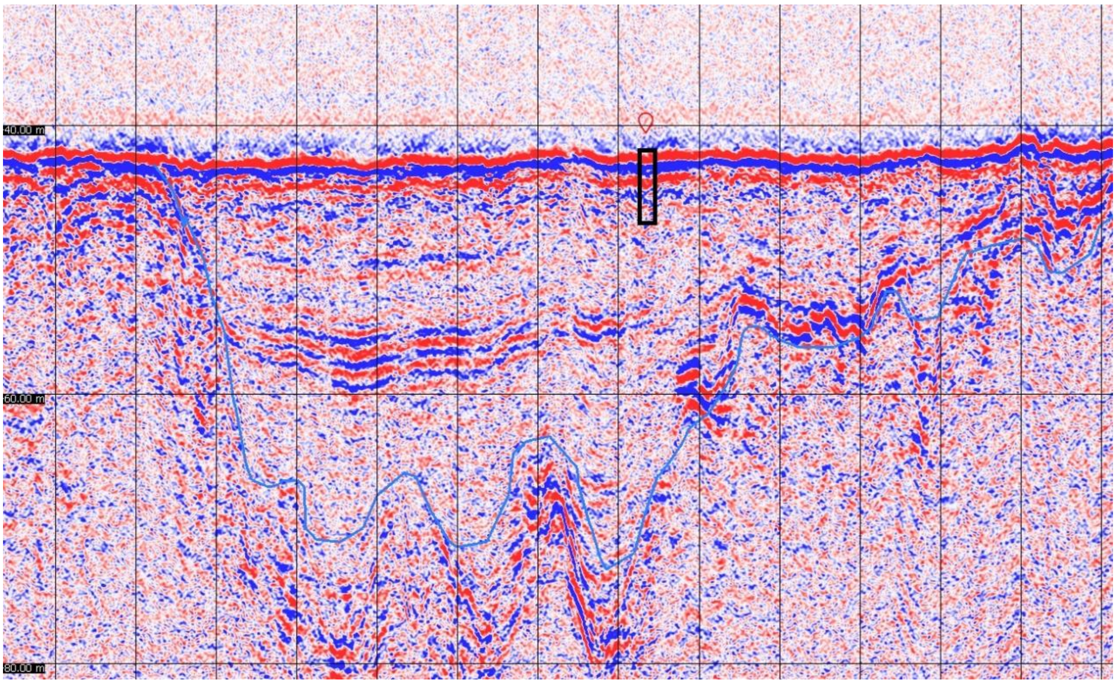

Plate 9-9 Location of core 201a showing approximate depth of penetration on line 15_008_UHRS0119_Final_Stack_Time.sgy. Blue line represents the base of Unit H3

9.7.1.7 In terms of overall form, the Annie Formation and basins within the Offshore Project form a northwest-southeast trending line, aligned with Gleann Mòr Bharabhais onshore, and with the channel visible between outcropping bedrock in the nearshore area (illustrated by **Plate 9-10**). It is likely that these features saw a phase of active erosion during the melting of the Devensian glaciers which covered the area, later infilled (offshore) by the Annie Formation.

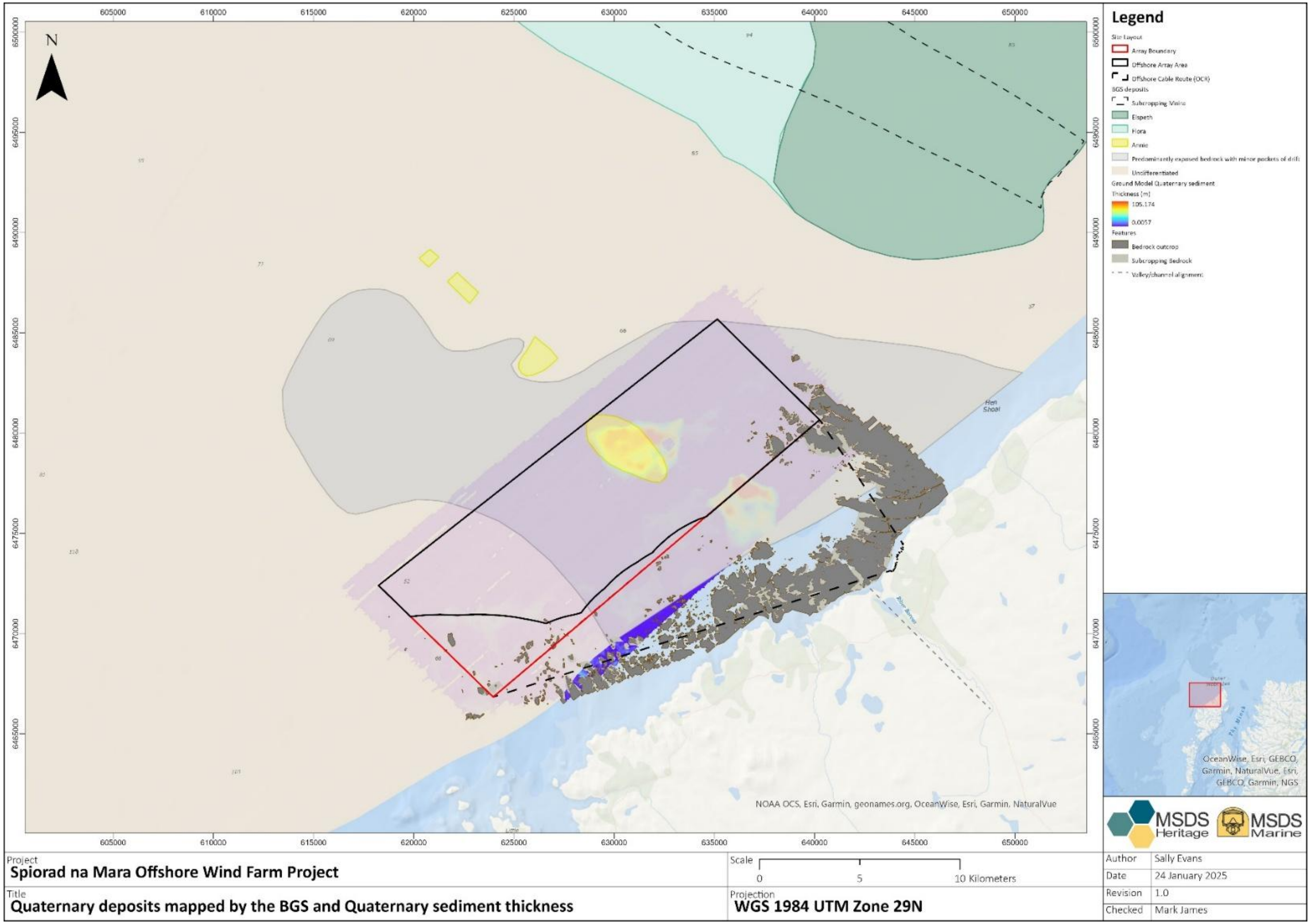

Plate 9-10 Quaternary deposits mapped by the BGS and Quaternary sediment thickness within the Offshore Project

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9.7.1.8 The undifferentiated Quaternary deposits may correlate in part with SBP Units U15, U17, U20 and UHRS Unit H4. Discussions by the BGS indicate that Quaternary deposits are characterised as 'undifferentiated' where they are too thin to express a recognisable seismic character (e.g. under 10 m in thickness, as within the Offshore Project) (Evans and McElvanney, 1989). Nevertheless, study of the surrounding sediments provides insights into their potential origins.

9.7.1.9 The following discussion examines the Quaternary stratigraphy of the Hebrides Shelf, as most relevant to the Offshore Project, focusing on the potential origins of the undifferentiated Quaternary deposits mapped therein by the BGS.

9.7.1.10 Quaternary deposits which are present in the area surrounding the Offshore Project, and around the northern part of the Outer Hebrides/*Na h-Eileanan Sia* in general are summarised in **Table 9-3**. The sequence of sedimentary deposition on the Hebrides Shelf during the Pleistocene is largely characterised by activities and processes of 2 major glacial events: the Anglian (478,000 to 424,000 Before Present (BP)) and Early Devensian (109,000 to 71,000 BP). On the inner shelf, upon which the Offshore Project lies, Quaternary deposits of the earlier Anglian glaciation have largely been eroded, with the vast majority relating to Devensian glacial activity and subsequent environments (Fyfe *et al*, 1993). Most of the deposits present within the area around the Offshore Project indicate glacial or glaciomarine depositional environments, with the latter being most common. As suggested by the general character of Quaternary sediments of the Hebrides Shelf, the undifferentiated deposits within the Offshore Project (provisionally including SBP Units U15, U17, U20 and UHRS Unit H4) are therefore likely to be largely glaciomarine or glacial in origin. The sediments reported by the geoarchaeological assessment within the Offshore Project have been characterised as glacial moraine sediments, laid down by retreating glaciers (Northland Power, 2024), however, the geotechnical campaign was limited by poor and shallow sample recovery (Aratellus, 2023), and potential for other deposit types remains, owing to the variation of glacial cover and sea level within the region (discussed below).

Table 9-3 Formations identified by the BGS within the wider area potentially present within the undifferentiated Quaternary deposits identified within the Offshore Project

Sequence	Description	Environment	Location	Epoch	Age
Catriona	Well-bedded and forming positive relief on the seafloor.	High-energy, shallow marine environment, possibly sandbanks.	Off the Butt of Lewis/*Rubha Robhanais* and extensive area off the west coast of Lewis.	Holocene to Pleistocene	Holocene to Pleistocene
Annie	Well-bedded, finely laminated, soft, silty clays.	Varying from cold to ameliorative. Contains evidence of the Loch Lomond Stadial.	Filling hollows and depressions within the Offshore Project and nearby.	Holocene to Pleistocene	Withdrawal of the Late Devensian ice sheet (Late Devensian to Early Holocene).
Sheena	Structureless to transparent acoustic character. Dark to very dark grey, pebbly, silty clay.	Glaciomarine to aquatic (potentially not fully marine). May represent a marine embayment in the Minch, deposited to the north of the ice sheet which laid down Fiona deposits.	Minch/*Mhaoil*	Pleistocene	Late Devensian
Fiona	Seismically structureless, hummocky.	Glacial (morainic), thought to represent mainland ice. Potentially subglacial or proglacial sediment.	Minch/*Mhaoil*		Late Devensian

Sequence	Description	Environment	Location	Epoch	Age
Morag	Well-bedded, soft to firm silty clay, with rare pebbles.	Nearshore glaciomarine with deposition likely north of the ice limit.	Minch/*Mhaoil* and North Lewis/*Eilean Leòdhais*		Late Devensian
Jean	Featureless and transparent acoustic character. Soft to stiff pebbly and slightly sandy silty clay.	Glaciomarine. Contains evidence of Arctic microfauna.	North Lewis Basin		Tentative pre-Late Devensian
Aisla	Structureless to chaotic acoustic character.	Glaciomarine.	North Lewis Basin		Tentative pre-Late Devensian
Elspeth	Featureless and transparent (generally) acoustic character. Stiff, sandy, silty clay, with pebbles.	Glaciomarine.	North Lewis Basin		Tentative pre-Devensian (potential Wolstonian)1
Flora	Structureless and slightly transparent acoustic character. Occasional bedding.	Glaciomarine.	North Lewis Basin		Undated
Shona	Structureless and transparent to well-layered acoustic character.	Glaciomarine.	Around Sula Sgeir High		Devensian to pre Devensian (MIS 2-6)
Moira	Wedges of acoustically structureless sediment.	Glacial (morainic) to glaciomarine.	Present and subcropping to the north of the Offshore Project.		Pre Devensian ice sheet?

Sequence	Description	Environment	Location	Epoch	Age
Kirsty	No distinctive seismic features and not sampled.		Restricted, north of Lewis/*Eilean Leòdhais*.		Unknown

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9.8 GLACIATION

9.8.1.1 Offshore Project lies in an area which saw Devensian ice cover during the Last Glacial Maximum (Bradwell *et al*, 2008) (LGM; *c*. 30,000 to 28,000 BP around the northern Hebrides (Clarke *et al*, 2022; Bradwell *et al*, 2021)). The exact reaches of the Late Devensian glacier in the area around the Offshore Project are unclear, with the ice sheet extents forming a topic of ongoing debate (Johnson *et al*, 1993; Clarke *et al*, 2022). However, recent work by Bradwell *et al*. (2021) and Clark *et al*. (2022) suggests that the area in the far north of Lewis, including Offshore Project, may have been ice-free by 26,000 BP, remaining exposed through the rest of the Devensian and into the Holocene (though minimum and maximum ice cover estimates vary). A series of ice sheet moraines have been mapped within the Offshore Project (visible within the MBES data) and likely represent the path of the retreating Devensian glaciers. The geoarchaeological assessment found evidence of sediments within the Offshore Project, including sands, clays, gravels and cobbles, which have been interpreted as evidence of glacial deposits laid down during deglaciation as moraine structures (Northland Power, 2024), demonstrating glacial activity within the Offshore Project and providing a broad likely date for these deposits.

9.8.1.2 Late Devensian ice cover was less extensive than earlier maxima of the period. Although the Loch Lomond stadial saw a readvance of ice in mountainous areas of the UK from *c*. 12,900 to 11,700 BP, this ice is not thought to have overrun north Lewis/*Eilean Leòdhais*, or Offshore Project, likely being restricted to the Uig Hills and North Harris/*Na Hearadh* in the Outer Hebrides/*Na h-Eileanan Sia* (Ballantyne, 2006; 2007; Bickerdale *et al*., 2018).

9.8.1.3 The interpretation of ice-free conditions since the LGM within the Offshore Project and north of Lewis/*Eilean Leòdhais* generally is supported by earlier BGS work. The area to the northwest of Lewis has been postulated by the BGS as potentially sub-aerially exposed during the Late Devensian (owing to the absence of ice cover and lower sea levels), with glaciomarine deposits further west and east (north of The Minch/*Mhaoil*) indicating the location of the sea or embayment's during the late glacial period (with the Sheena Formation potentially representing the embayment in The Minch/*Mhaoil* and the Fiona Formation representing the Late Devensian glaciers further south; **Table 9-4**). Thus, while there are a range of glacial and glaciomarine deposits within the wider area, it is possible that the Offshore Project saw periods of sub-aerial exposure from the Late Devensian onwards. If exposed during this period, Offshore Project is likely to have experienced arctic conditions in the late glacial period (Stoker *et al*., 1993), though climatic amelioration during the Early Holocene would have presented warmer conditions.

9.8.1.4 The presence of deposits within the Offshore Project which span this period, in particular the Annie Formation, which is thought to have been laid down from the Late Devensian to

Early Holocene, therefore indicates potential for terrestrial evidence to be present (though the Formation itself is largely characterised by marine depositional conditions).

9.8.1.5 The dates of submergence and periods of Occupation of the Outer Hebrides/*Na h-Eileanan Sia* are therefore key for further developing understanding of the archaeological potential of the Offshore Project. This is discussed further below.

9.9 SEA LEVEL DATA AND MARINE DEPOSITS

9.9.1.1 Data relating to past sea levels can be correlated with geological and glaciogenic data to inform our understanding of palaeolandscape development during the Late Quaternary and Early Holocene. Analysis of reconstructed palaeolandscapes can inform subsequent discussions relating to human Occupation and archaeological potential.

9.9.1.2 Extensive intertidal peats are known from the shorelines around the Outer Hebrides/*Na h-Eileanan Sia*, demonstrating the presence of now submerged palaeolandscapes (Richie, 1985). There are numerous Sea Level Index Points (SLIPs) located on the Outer and Inner Hebrides/*Na h-Eileanan Sia* and the northwest coast of Scotland/*Alba* to inform understanding of sea level change. The SLIPs generally date to after the LGM (*c*. 13,000 BP), due to difficulty in accessing enough deeply buried offshore samples, though a small number provide evidence for the earlier Late Devensian (ranging from *c*. 18,700 to 11,700 BP). Therefore, SLIPs are more useful for informing on the relative sea level (RSL) of the Early Holocene.

9.9.1.3 Sea level studies for this period are complex and subject to a wide range of variables. One of the key factors is that of glacial isostatic adjustment (GIA), relating to the viscoelastic response (deformation) of Earth structures arising from glacial ice-load (Bagge *et al.*, 2021). The British-Irish ice sheet developed outward from the Scottish Highlands during the Dimlington stadial (29,000 to 14,700 BP), extending as far south as the Norfolk coast and the Western Approaches. Northern parts of Britain were therefore subject to greater depression and rebound, with localised variations in ice thickness potentially causing further local variations in RSL (E.g. as postulated by Jordan *et al.*, (2010) though no evidence of local variations in RSL was found by this study).

9.9.1.4 Shennan *et al*, (2018) have produced a recent and extensive study of RSL in Britain and Ireland since the LGM. Their study, incorporating over 2,100 data points including SLIPs and marine and terrestrial limiting data, provides regional insights into RSLs across the British Isles primarily covering the Late Devensian and Holocene. A sub-sample of 12 SLIPs was consulted to inform the discussion of this sub-section (**Plate 9-11**). A gazetteer of the sub-sample is included in **Table 10-1**. The sub-sample represents those SLIPs for the Outer Hebrides/*Na h-Eileanan Sia* within this dataset and therefore most relevant to the Offshore

Project's RSL chronology. Additional SLIPs from the west coast of Scotland are also relevant and were reviewed to compare with the Outer Hebrides/*Na h-Eileanan Sia* SLIPs. Wider sea level studies have also been referred to, particularly where they inform pre-Devensian RSL.

9.9.1.5 Sea levels have seen vast fluctuations over previous glacial cycles. Close to Offshore Project, on the northwest coast of Lewis/*Eilean Leòdhais*, are well-developed rock-cut platforms, lying 7.0 to 10 m Ordnance Datum (OD) above current sea level. These platforms are overlain by tills, organic deposits, raised beach gravels and further till layers (Sutherland, 1984). The sequence of deposits is thought to have formed over a period spanning MIS 6 to 3 (191,000 to 29,000 BP) and therefore demonstrates the types of sediment possibly laid down from the Late Wolstonian to Early-Mid Devensian and remaining extant within the onshore landscape (Smith *et al*., 2019). Offshore, there is also evidence of lower sea levels. Pre-Late Devensian rock platforms off the west coast (near to St Kilda/*Hiort* and Sula Sgeir) are present at depths of 120 m, 125 m and 155 m OD (Smith *et al*., 2019).

9.9.1.6 Devensian sea level changes are likely to have been complex and a single SLIP from Skye/ *An t-Eilean Sgitheanach* (UID: AA44938 – not reproduced) indicates a raised sea level of 16.85 m (RSL) around 18,700 BP (during the Dimlington Stadial), although a note on this record mentions a possible error in the data (Shennan *et al*., 2018).

9.9.1.7 The remaining SLIPs from the surrounding area relate to more recent dates. Studies indicate that sea levels remained low during the Late Devensian and, during the Loch Lomond stadial (Younger Dryas), water depths were thought to be *c*. 120 m lower than present (Peacock *et al*., 1996; Smith *et al*., 2019: 4). Submerged Late Devensian and Holocene (MIS 2 to 1) rock-cut platforms in some areas overlain by till cover are reported by Smith *et al.*, (2019:8)around the Outer Hebrides/*Na h-Eileanan Sia*. This ties in with SLIPs for the island chain, which demonstrate lower, but rising, sea levels through the Holocene, with RSL of -5.0 to -3.0 m between 8,490 BP (Mesolithic period) and 5,480 BP (Neolithic), rising to -2.0 to -1.0 m OD between 5,143 BP and 737 BP and less than -1.0 m OD over the last millennium.

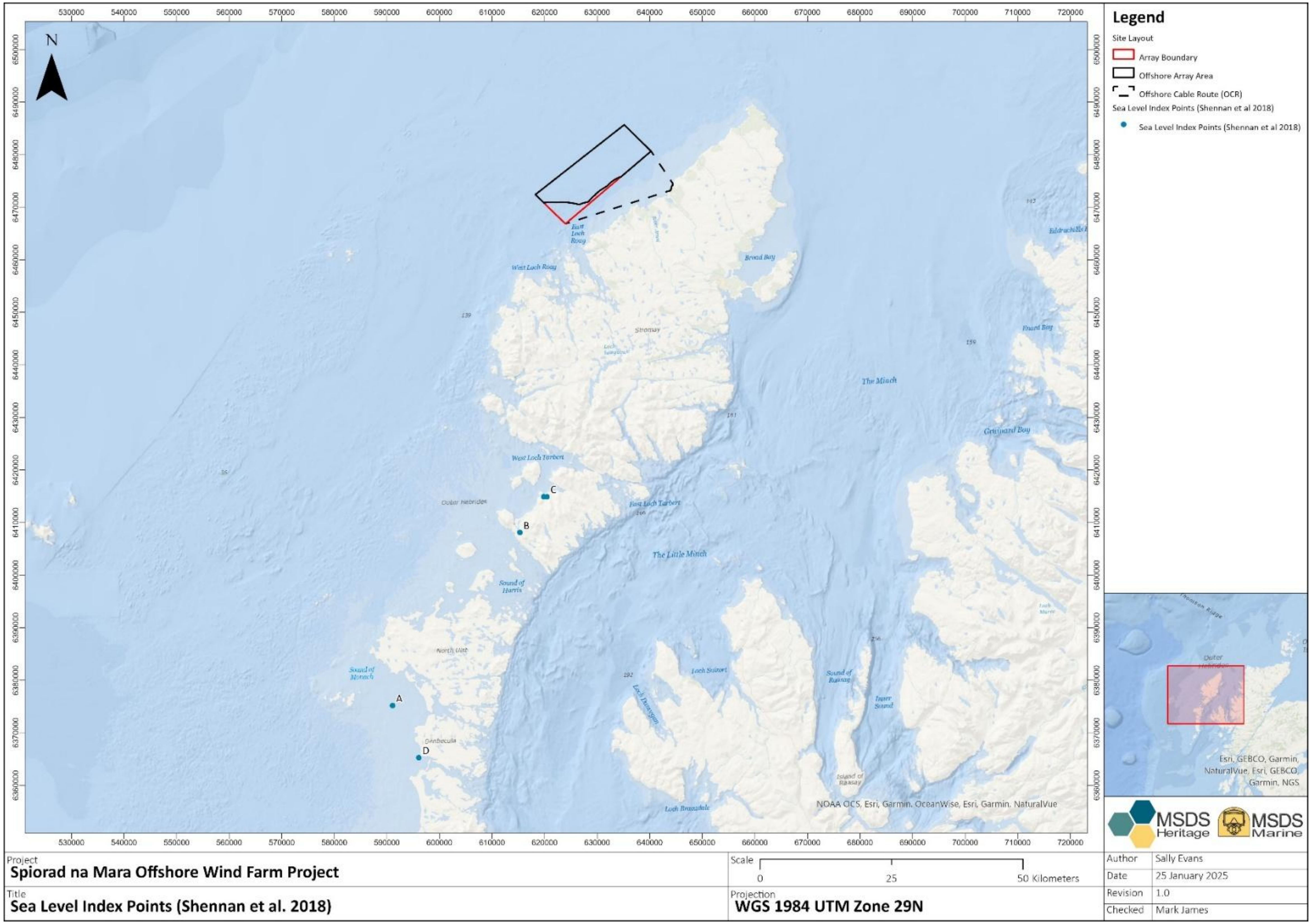

Plate 9-11 Sea Level Index Points (Shennan et al. 2018)

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9.9.1.8 On the Isle of Harris/*Na Hearadh* (connected to Lewis/*Eilean Leòdhais*), samples from coastal wetland sites at Northton and Horgabost may hold evidence of an extreme flooding event around 8,348 to 7,982 BP, which has been postulated to tie in with either the Holocene Storegga tsunami (off the Norwegian coast) or to the discharge of Lake Agassiz–Ojibway (in northern Canada), though neither have been verified (Smith *et al.*, 2019: 15). These Hebridean sites also demonstrated small oscillations in RSL during the Holocene, generally exhibiting a trend of rising sea levels but with evidence of marine regression around 5,500 BP, transgression by *c.* 5,450 to 4,861 BP and with a later, small regression.

Table 9-4 Sea Level Index Points from the Outer Hebrides

MSDS ID	Sample ID	Source	Age (BP)	RSL (m OD)	Period
A	SRR1224	Ritchie 1985	8,490	-3.77	Mesolithic
B	Beta149189	Jordan et al 2010	8,192	-3.33	Mesolithic
C	Beta140969	Jordan et al 2010	6,302	-3.43	Mesolithic
D	SRR1222	Ritchie 1985	5,924	-5.0	Mesolithic
C	Beta127972	Jordan et al 2010	5,480	-3.36	Neolithic
C	Beta140970	Jordan et al 2010	5,143	-1.81	Neolithic
B	Beta149188	Jordan et al 2010	3,178	-1.22	Bronze Age
C	Beta140971	Jordan et al 2010	2,119	-1.03	Bronze Age
C	Beta140968	Jordan et al 2010	737	-1.42	Late Norse
C	Beta140972	Jordan et al 2010	685	-0.31	Late Norse
C	Beta120965	Jordan et al 2010	491	-0.63	Medieval
C	Beta120964	Jordan et al 2010	126	0.17	Post-medieval

9.9.1.9 The SLIPs are in general agreement with GIA models, though some instances of the GIA models placing sea levels lower than SLIPs have been identified. The Kuchar and Bradley GIA models, for example (**Plate 9-12**), chart steady rise from -24 to 30 m OD at *c.* 11,000 BP, with the Bradley model indicating an RSL of 0.0 m from around 4,000 BP and the Kurchar model indicating RSL of approximately -2.0 m at this time (up from -4.0 m at 6,000

BP). The latter concurs closely with the GIA of Sturt *et al*, (2013) (as used recently by Blankshein (2022)). Sea level curves, informed by the Kuchar and Bradley models, were produced by Smith *et al*.(2019) and are reproduced here by **Plate 9-12**.

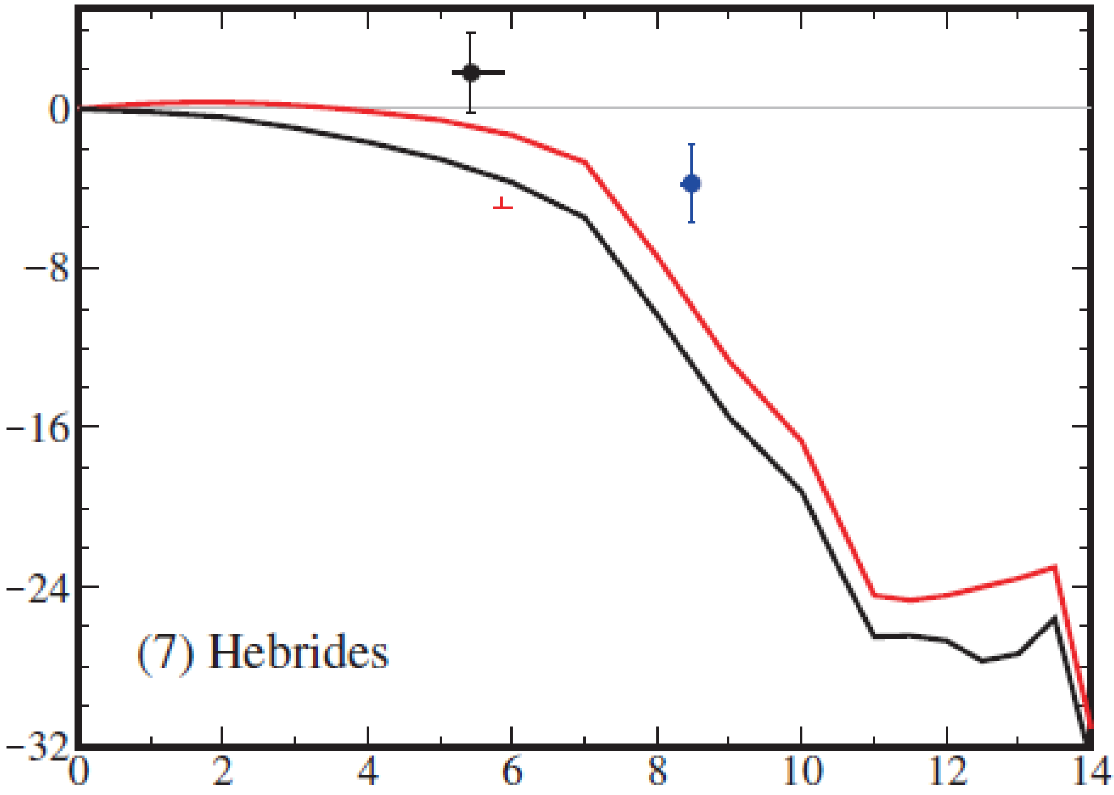

Plate 9-12 GIA models from Kuchar (black line) and Bradley (red line) for the Hebrides, showing SLIPs for the area (crosses), from Smith *et al*. (2019). (Y-axis: RSL; X-axis: years BP) (blue lines indicate data points discussed in the text)

9.9.1.10 While these sources are in broad agreement, there remains some disparity in the wider evidence base for RSL studies in the region. 2 SLIPs not included within the dataset presented by Shennan *et al*, (2018) were presented in an earlier study by Peacock *et al*, (1992) and an RSL curve based on these points was produced by Lambeck (1995) (**Plate 9-13**). The SLIPs come from 2 vibrocores taken from the area south of St Kilda/*Hiort*. The RSL curve based on palaeoenvironmental evidence within these cores (taken to indicate water depths at the core locations) indicates much lower RSL in the Late Devensian and Early Holocene. The data from these cores suggests RSL of *c*. -65 m at 11,000 BP (over 30 m lower than the models of Kuchar and Bradley) and RSL of between -40 to -45 m at 9,000 BP, continuing to rise rapidly to *c*. 6,000 BP. Thereafter, water levels are thought to have been at *c*. -10.0 m, slowly rising to current sea level from *c*. 3,000 BP.

9.9.1.11 The considerable variation in postulated sea levels for the Outer Hebrides/*Na h-Eileanan Sia* complicates confident identification of periods when the Offshore Project may have been sub-aerially exposed, thus impacting assessment of archaeological potential.

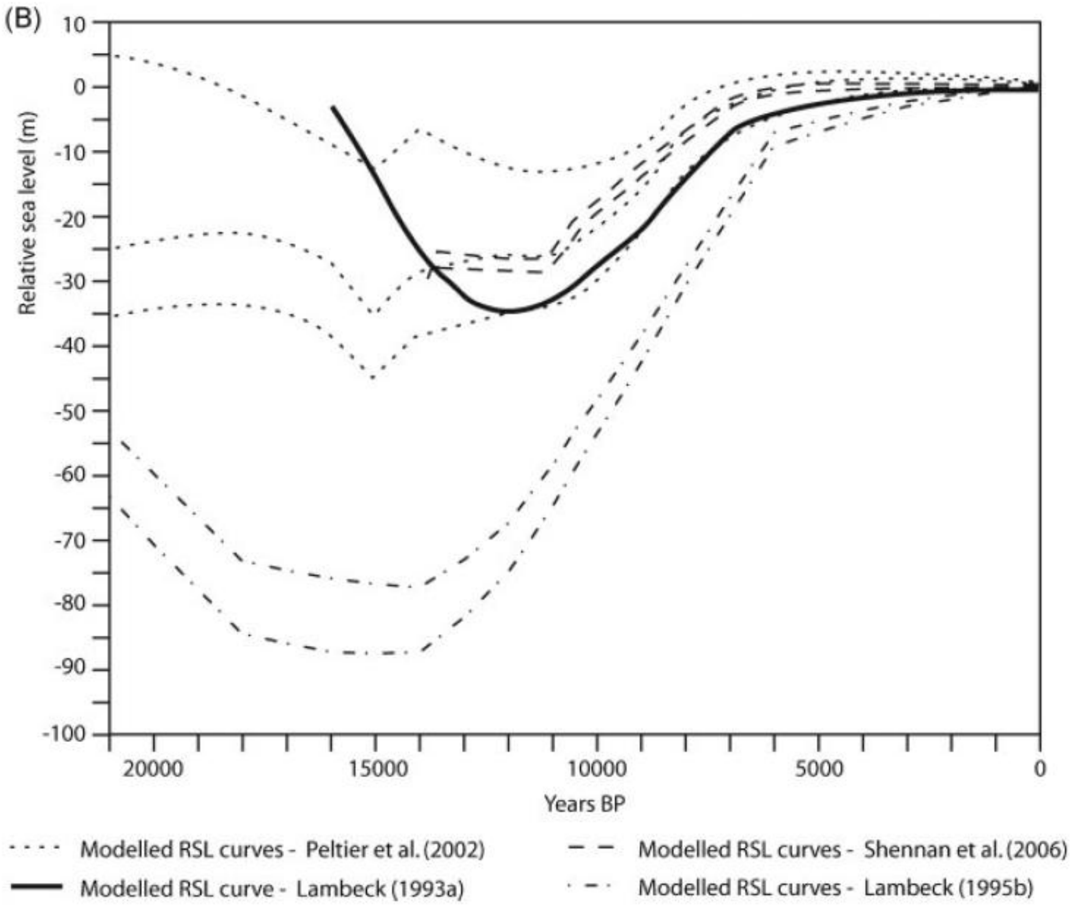

Plate 9-13 Modelled RSL curves from Jordan et al (2010) (blue lines indicate data points discussed in the text)

9.10 ARCHAEOLOGICAL CONTEXT AND SEA LEVELS

9.10.1.1 While Lower Palaeolithic evidence is well known within England, in a Scottish context the earliest current secure evidence of human presence is from the Late Upper Palaeolithic (Finlayson and Edwards, 2003; Saville *et al*., 2012). This also includes Offshore Project of Rubha Port an t-Seilich, Inner Hebrides, which has produced evidence for activity potentially dating to around 12,000 BP (during the Late Upper Palaeolithic - Late Devensian (Loch Lomond stadial)/Early Holocene) (Mithen *et al*., 2015). Thus, while there is no current evidence for Palaeolithic activity in the Outer Hebrides/*Na h-Eileanan Sia*, the potential exists for such remains to occur owing to the wider evidence for human activity during this period.

9.10.1.2 On the Outer Hebrides/*Na h-Eileanan Sia*, the earliest current evidence dates from the Mesolithic period (Gregory *et al*., 2005) and, on Lewis and Harris/*Leòdhas agus Na Hearadh*, 3 Mesolithic sites have been identified. At Northton, Harris, midden deposits, containing stone tools, flint knapping debris, charred hazelnut shells and animal bone, have been dated to between *c*. 9,000 to 8,000 BP (7,000 to 6,000 cal. BC) and other Late Mesolithic remains have also been identified at Bagh an Teampuill, Harris/*Na Hearadh*, and Traigh na Beirgh, Lewis/*Eilean Leòdhais* (Church *et al*., 2011a; 2011b). Most other evidence is in the form of palaeoenvironmental remains, which provide proxy indications of human activity in the Mesolithic period through changes in the pollen record associated with episodic horizons of charcoal, indicative of burning (Edwards, 1996). There is extensive evidence of prehistoric activity around the coastal strip close to the Offshore Project including settlement, burial and subsistence activities. These remains include shell middens, settlements and numerous burial cairns, as well as field systems and other prehistoric structures, dating from the Neolithic (*c*. 3,800 to 2,500 BC) period onwards (Burgess and Church, 1997).

9.10.1.3 Sea levels during this period may have been much lower than present levels; *c*. - 40 to -45 m OD at 9,000 BP (following data presented by Lambeck (1995) and Peacock *et al*., (1992)) and potentially lower at 12,000 BP, with the most extreme lower estimate by Lambeck of -75 m (**Plate 9-13**). Estimates vary vastly, however, depending on the RSL curve and data used, with others indicating an RSL of -15 m OD at 9,000 BP and *c*. -27 m OD at 12,000 BP (**Plate 9-12**), and nearby SLIPs indicating a RSL of *c*. -3.7 m at 8,500 BP. The SLIPs indicate slowly rising sea levels throughout prehistory and into the historic period (**Table 9-4**).

9.10.1.4 The -75 m contour lies offshore from The Offshore Project (the deepest parts of the Offshore Project are -70 m). The -45 m contour lies around the eastern edge of the Array Area and western part of the OCAS and the -15 m contour lies close to the coast (*c*. 1.0 to 2.0 km from the shore). The differences in sea level estimates for this period make precise understanding of sub-aerial exposure during the prehistoric period difficult. However, all estimates agree that sea levels were lower (to some extent) during this period, indicating that potential increases with proximity to the shore (as all sea level data indicates some degree of exposure in this area). The nearshore area has been highlighted as one of potential by previous studies (Wickham-Jones and Dawson, 2006).

9.10.1.5 Units H15, 17, 20 and H4 are furthest from the shore and principally lie below the -45 m contour, though, depending on the RSL curve used, these may have been exposed in the Late Glacial/Late Upper Palaeolithic period.

9.10.1.6 The -45 m contour passes through the nearshore side of the Array Area, crossing the southernmost large depression infilled by Unit H3 (interpreted as the Annie Formation). The Annie Formation was in active deposition during this period (Late Devensian to Early

Holocene). If sea levels presented by Lambeck (1995) and Peacock *et al*, (1992) are correct, this may indicate exposure of parts of the Unit H3 (Annie Formation) during the Early Mesolithic, indicating potential for archaeological or palaeoenvironmental remains dating to this period. However, the character of this deposit is thought to be marine and the geoarchaeological assessment for the recent geotechnical campaign found low geoarchaeological potential from the cores taken from this location (201, 201a), owing to the interpretation of the sediments within as of glaciofluvial moraine sediment laid down at the glacial margin (Northland Power, 2024).

9.10.1.7 The area inshore of this contour principally lies in the zone in which poor data quality (of the nearshore data) has hindered interpretation. As such, the deposits, their interpretation and archaeological potential cannot be defined with confidence. While outcropping and subcropping bedrock is common in this area, demonstrating an absence of sediment cover, pockets of Quaternary sediment do survive. Some areas of potential channelling cut into the bedrock are visible and, while sediment cover is sometimes thin in these areas (Aratellus, 2024: 45), there remains potential for deposits of archaeological and palaeoenvironmental interest to be present. The areas with highest potential for deposits of interest may be those which have been afforded more shelter from erosion, for example, by the bedrock exposures (**Plate 9-14**).

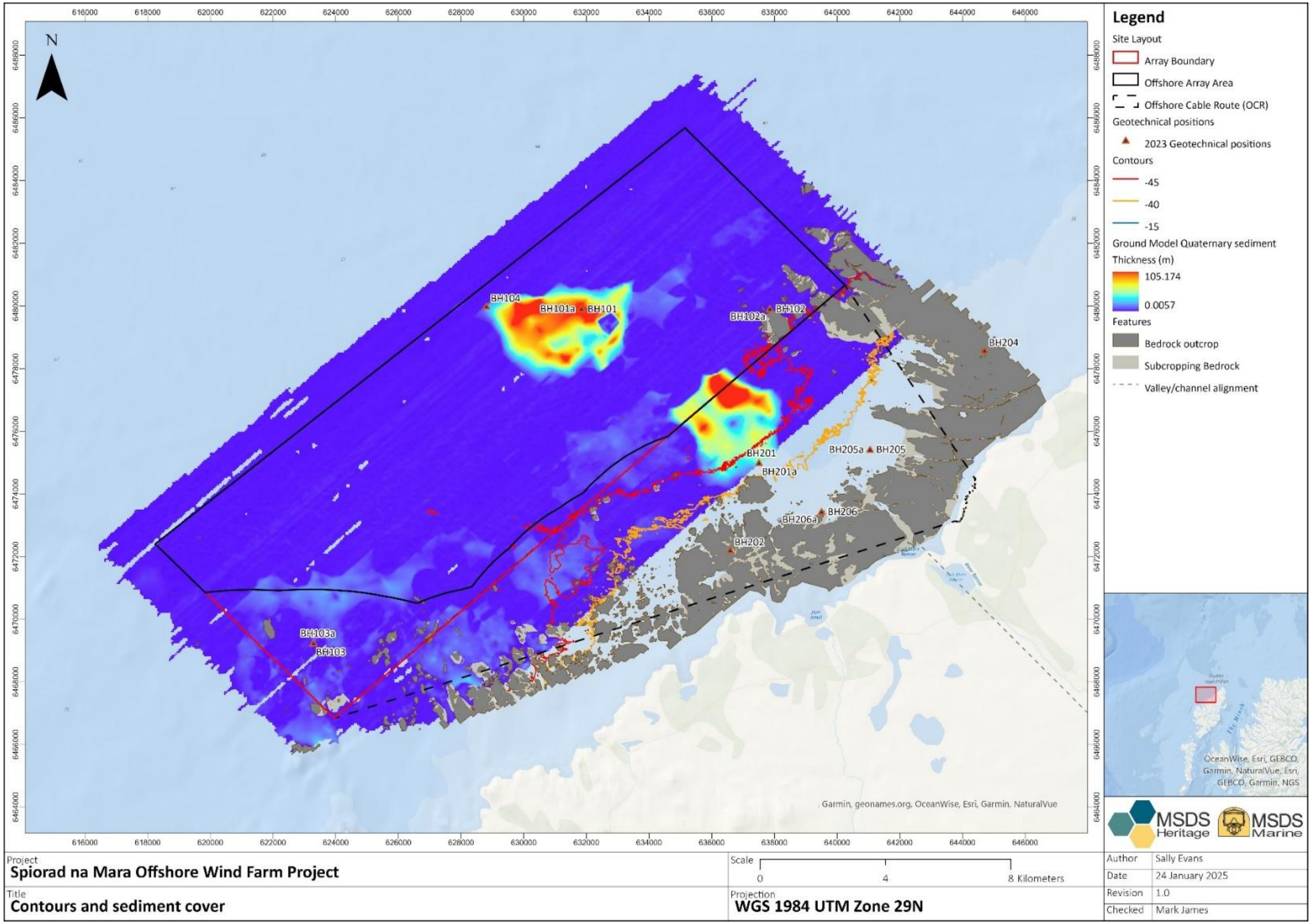

Plate 9-14 Contours and sediment cover

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9.11 SUMMARY

9.11.1.1 The SBP and UHRS data has been used to map Quaternary sediments within the Offshore Project. The boundary between the Quaternary sediments and earlier bedrock geology is clear within the seismic data and the isopachs which show the depth of Quaternary sediment are therefore considered accurate. The data demonstrates relatively thin sediment cover across the Offshore Project, with 2 deep basins of sediment where depths extend to *c.* 110 m.

9.11.1.2 Aratellus picked multiple horizons within the seismic data. While those in the basins and northeast parts of the Offshore Project were based on good quality data, those in the southwest are not considered reliable, due to poor data quality. However, most of the separate horizons picked within the southwest data extents now lie beyond the Offshore Project boundary.

9.11.1.3 Horizons picked within the SBP data include U05 and U30 (rock/bedrock), U10 (seabed sediments) and U15, U17 and U20 (variety of Quaternary sediments). Units H1 (seabed), H3 (well-bedded sediments within the two deep basins) and H4 (thin upper layer) were also mapped within the UHRS data.

9.11.1.4 The nature of these sediments has been interpreted here in relation to previous works and geotechnical investigations. It is thought that:

- U10 represents the modern seabed sediments;
- H3 represents the ba;
- U15, U17 and U20 and H4 represent Quaternary sediments, undifferentiated by the BGS, but with those in the wider area indicating primarily glacial or glaciomarine origins (mostly relating to the Devensian);
- U05 and U30 represents rock/bedrock.

9.11.1.5 The nearshore data was very poor and neither the depth of sediment nor internal horizons could be mapped with any confidence.

9.11.1.6 The history of glaciation in the area suggests that Offshore Project was ice-free by *c.* 26,000 BP, remaining so thereafter. Sea level estimates vary and may have been between -75 to -27 m (or higher) below current levels in the Late Upper Palaeolithic (concurrent with the earliest evidence of human activity in Scotland). Estimates of -45 m, -15 m and -3.5 m at *c.* 9,000 BP correlate with the earliest local evidence for Mesolithic activity. It is therefore not clear at what time the Offshore Project became submerged and therefore uninhabitable. This influences the archaeological and palaeoenvironmental potential of the deposits within the Offshore Project. The sediments within the nearshore area have the highest potential to contain evidence of sub-aerial exposure, though, depending on the RSL data used, the whole Site has the potential to have been exposed at 12,000 BP and the whole OCAS exposed at 9,000 BP. However, these are the most extreme estimates and it is possible that sea levels were higher, leaving only the nearshore parts of the OCAS exposed during the Mesolithic, supporting the greater archaeological potential of that area.

9.11.1.7 The poor quality of the nearshore data and the paucity of sample recovery from the earlier geotechnical campaign therefore limits the ability to understand archaeological potential, as the nature of deposits in this area have not been confidently characterised. Further work is recommended to investigate this area and mitigate any impacts if sediments of interest are identified.

10 MITIGATION

10.1.1.1 This section provides recommendations for the robust, but proportional, mitigation of impacts to the historic environment for low, medium, and high potential anomalies, and magnetic anomalies, identified within the geophysical dataset. As outlined in Section 3 recommended mitigation for these anomalies will be through the implementation of AEZs, TAEZs and AAPs. Mitigation relevant to the palaeolandscape is discussed in Section 10.8.1.1.

10.1.1.2 The mitigation strategies recommended within this report are based on the available data, which includes full coverage (100%) MBES and SSS. Magnetometer data were collected at the same line spacing as the SSS and MBES which means there is potential for items of buried material of archaeological interest to be present within the assessment area that is not visible within the current dataset, or for magnetic anomalies to not be represented in their true position. In addition, the underlying igneous geology meant that large areas of the seabed were unable to be assessed for ferrous anthropogenic anomalies.

10.1.1.3 However, the data serve to characterise the potential of the area with respect to the requirement for exclusion zones. Mitigation will be developed through each phase of survey works as detailed within Section 11.

10.2 LOW POTENTIAL ANOMALIES

10.2.1.1 Low potential anomalies have been identified as potentially anthropogenic in origin but unlikely to be of archaeological significance and no exclusion zones are recommended for these anomalies. Should material of potential archaeological significance be identified during the course of pre-construction and construction works they should be reported under an appropriate protocol for archaeological discoveries such as the *Crown Estates Protocol for Archaeological Discoveries:* Offshore *Renewables Projects* (The Crown Estate, 2014) or a project specific protocol that considers the individual requirements of the Offshore Project.

10.3 ARCHAEOLOGICAL EXCLUSION ZONES

10.3.1.1 A total of 4 medium potential anomalies have been identified within the geophysical survey data extents, 1 within the OCAS, 2 within the Array Area, and 1 within the data extents. The anomalies have been identified as likely to be of anthropogenic origin and potentially of archaeological significance. The anomalies have been recommended AEZs based on the size of the anomaly, the extents of any debris, the potential significance of the anomaly, the potential impact of the development and the seabed dynamics within the area.

10.3.1.2 Dependant on the form of anomalies, AEZs will either be recommended as a radius from the centre point of the anomaly or as a distance from the extents. Particularly in the case of shipwrecks, which tend to be longer in length than width, the use of a circle provides unequal protection around the extents. This not only impacts the protection afforded but does not represent proportional mitigation.

10.3.1.3 In total 4 AEZs relating to a medium potential anomaly has been recommended within the geophysical survey data extents.

10.3.1.4 Anomalies and their recommended exclusion zones are detailed in **Table 10-1** and the distribution presented in **Plate 10-1**. Note, where discrepancies exist between the position within different datasets, the position deemed to be most accurate has been used, typically that derived from the MBES data.

Table 10-1 Archaeological Exclusion Zones within the geophysical survey data extents

Anomaly ID	Description	Potential	WGS84 UTM Zone 29 N		AEZ (m)
			X	Y	
SP24_020	Potential debris	Medium	635544.3	6481415.6	35 (radius)
SP24_024	Mound	Medium	623095.7	6467426.9	25 (extents)
SP24_025	Potential debris	Medium	634299.7	6472656.0	35 (radius)
SP24_026	Mound	Medium	628322.9	6474615.5	35 (radius)

10.4 TEMPORARY ARCHAEOLOGICAL EXCLUSION ZONES

10.4.1.1 TAEZs are recommended where an anomaly is not visible in the dataset but is known to exist, where the position cannot be determined with enough accuracy for refined exclusion zones, or where the extents are not fully known. They are often larger than AEZs but are identified as temporary as they are highly likely to be altered following higher resolution or full coverage data assessment or ground truthing, they will remain in place until alterations have been formally agreed.

10.4.1.2 No TAEZs are recommended for records originating from the UKHO, Canmore, or the HER. All record locations within the geophysical data extents were reviewed, where a feature was visible on the seabed this was assessed for archaeological potential with mitigation recommended as appropriate. Where no feature was visible on the seabed the records were assessed, and in all instances, it was determined unlikely that remains were present, but not visible, on the seabed.

10.4.1.3 No TAEZs are recommended for magnetic anomalies that do not have a strong correlation with a seabed feature due to the 100 m line spacing and the impact on the data of the underlying geology. However, it should be noted that this is not due to the likely absence of magnetic anomalies that may be of potential archaeological interest. Mitigation should take the form of a commitment to the recommendations for further work in Section 11, in particular those relating to the collection, and assessment, of magnetometer data.

10.5 AREAS OF ARCHAEOLOGICAL POTENTIAL

10.5.1.1 No formal mitigation in the form of exclusion zones is recommended for AAPs, however they serve to highlight the potential for material of archaeological interest to be identified following the collection of higher resolution, or denser, geophysical survey data. These could originate, for example, from the identification of a high concentration of magnetic anomalies where the positions cannot be determined and with no correlating seabed feature.

10.5.1.2 No AAPs are recommended within the geophysical survey data extents. However, due to the wide spacing of the magnetometer data, and the impacts of the underlying geology, there should be a general awareness that following the collection of denser data there is potential that additional anomalies of potential archaeological interest will be identified.

10.6 NOTES ON EXCLUSION ZONES

10.6.1.1 Exclusion zones have been recommended based on the available evidence as interpreted by an experienced and qualified maritime archaeologist, they are to be agreed between the developer, the archaeological curator, and the regulator. Exclusion zones are implemented to protect, in-situ, potentially archaeologically significant material.

10.6.1.2 Where an exclusion zone has been implemented, no development work impacting the seabed is to take place within the prescribed area. Should an exclusion zone impact the development program it is recommended that a program of ground truthing be undertaken to establish the identity of an anomaly in order that the potential archaeological significance can be assessed by a qualified and experienced archaeologist. Following identification and assessment, the exclusion zone can be re-assessed to ensure mitigation is appropriate to the archaeological significance of the anomaly.

10.7 PROTOCOL FOR ARCHAEOLOGICAL DISCOVERIES

A project specific protocol for archaeological discoveries, based on the *Crown Estates Protocol for Archaeological Discoveries: Offshore Renewables Projects* (The Crown Estate, 2014), has been produced (**Protocol for Archaeological Discoveries, Volume 3**). The protocol should be applied across the scheme. Such protocols provide a means of identifying previously unidentified archaeological remains and are an important part of the mitigation process.

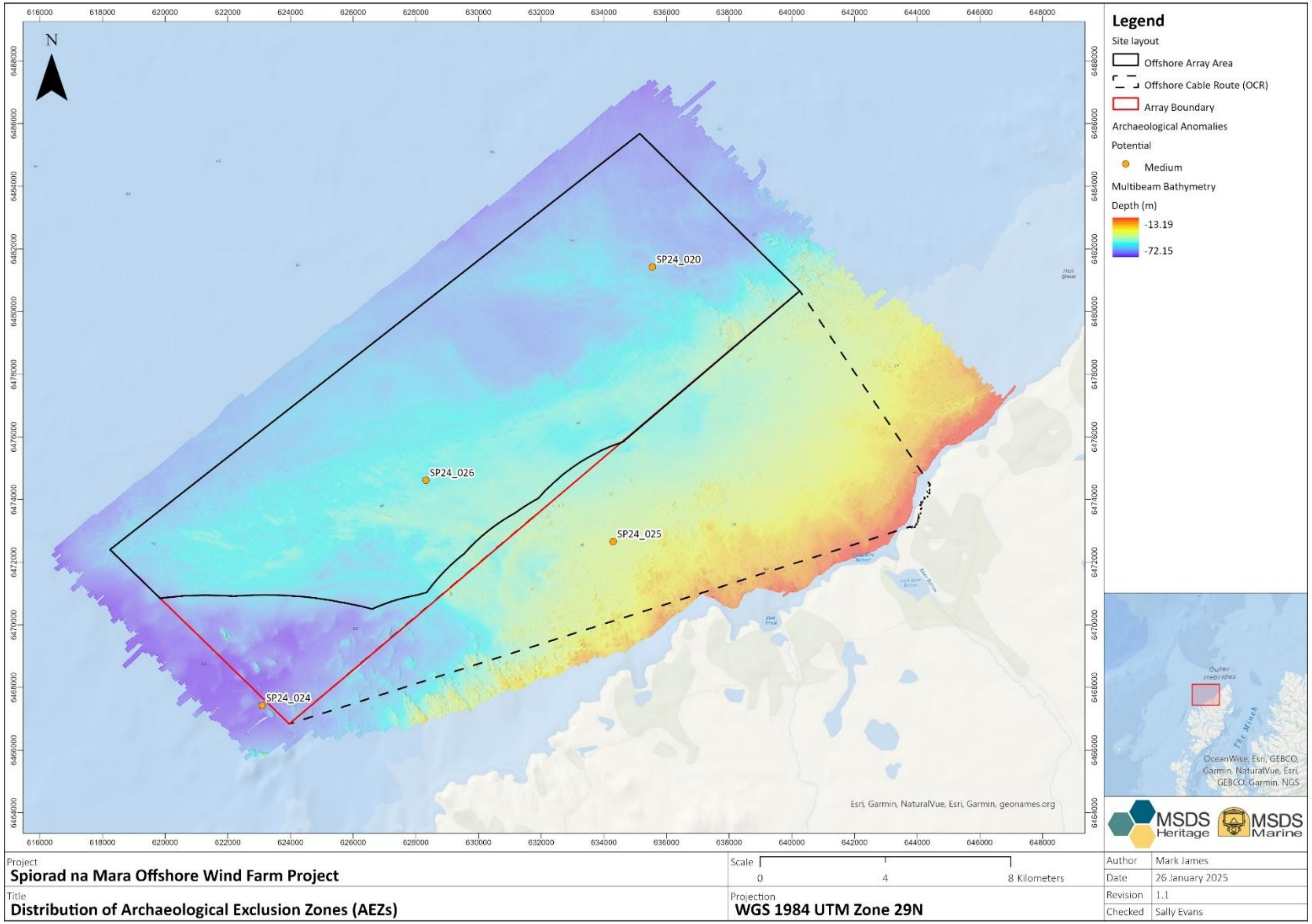

Plate 10-1 Location of Archaeological Exclusion Zones

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10.8 PREHISTORIC ARCHAEOLOGY AND PALAEOENVIRONMENTAL REMAINS

10.8.1.1 It is recommended that further geotechnical and geoarchaeological work should be undertaken to inform the potential of the Offshore Project, and to provide sample material for geoarchaeological analysis should mitigation be required. These cores should sample areas of potential, in particular the nearshore area owing to its possible higher potential.

10.8.1.2 It is recommended that 3 core locations (illustrated on **Plate 10-2**) are targeted for archaeological purposes during the next planned geotechnical campaign. The locations recommended target:

- Archaeological Core (AC) 1: a probable former channel feature (illustrated on **Plate 9-10**). Such features are often conducive to the deposition and survival of palaeoenvironmental information, and often formed foci for past communities. The recommended core location targets an area where sediment cover is indicated by an absence of outcropping/subcropping bedrock; and nearby features may have provided shelter from erosion. The area is also a likely route for the cable, and therefore samples along this route provide the opportunity for mitigation for cable related impacts;
- AC2: The area in the lee of a likely former bedrock 'island' at the mouth of the aforementioned channel. This bedrock feature is likely to have provided some protection from erosion, and such features may have been foci for past human activity;
- AC3: The southernmost basin, owing to the potential of the infill of the basins to span the Late Glacial and Early Holocene period, and with the potential for the nearshore basin to have been partially exposed during this period (dependent on the RSL at that point).

10.8.1.3 These locations have the potential to provide palaeoenvironmental information about the Offshore Project, including information on sea levels (which are poorly understood in the area), which in turn informs archaeological potential. The archaeological background of the wider area, including concentrations of sites along the coastal strip also supports the collection of additional data from the Offshore Project, to further understanding of project impacts and allow opportunities to mitigate any such impacts.

10.8.1.4 2 of the locations have been identified without the use of seismic data (AC1 and AC2), as the data for the nearshore area was too poor to provide useful information. Should further seismic data become available this should be used to further refine core locations, with archaeological input. Additionally, archaeological input should be sought while planning the geotechnical campaign in order that methods for ensuring archaeological input, review and analysis of suitable core material are possible. This input should also include a review of the core locations once the final methods for sample collection are chosen, as different sampling methods (e.g. vibrocores and boreholes) allow different depths of penetration, and as such samples may be better suited in different locations to those depicted here. This may be the case if additional seismic data becomes available, or in the case of AC3 which has been located based on the existing seismic data.

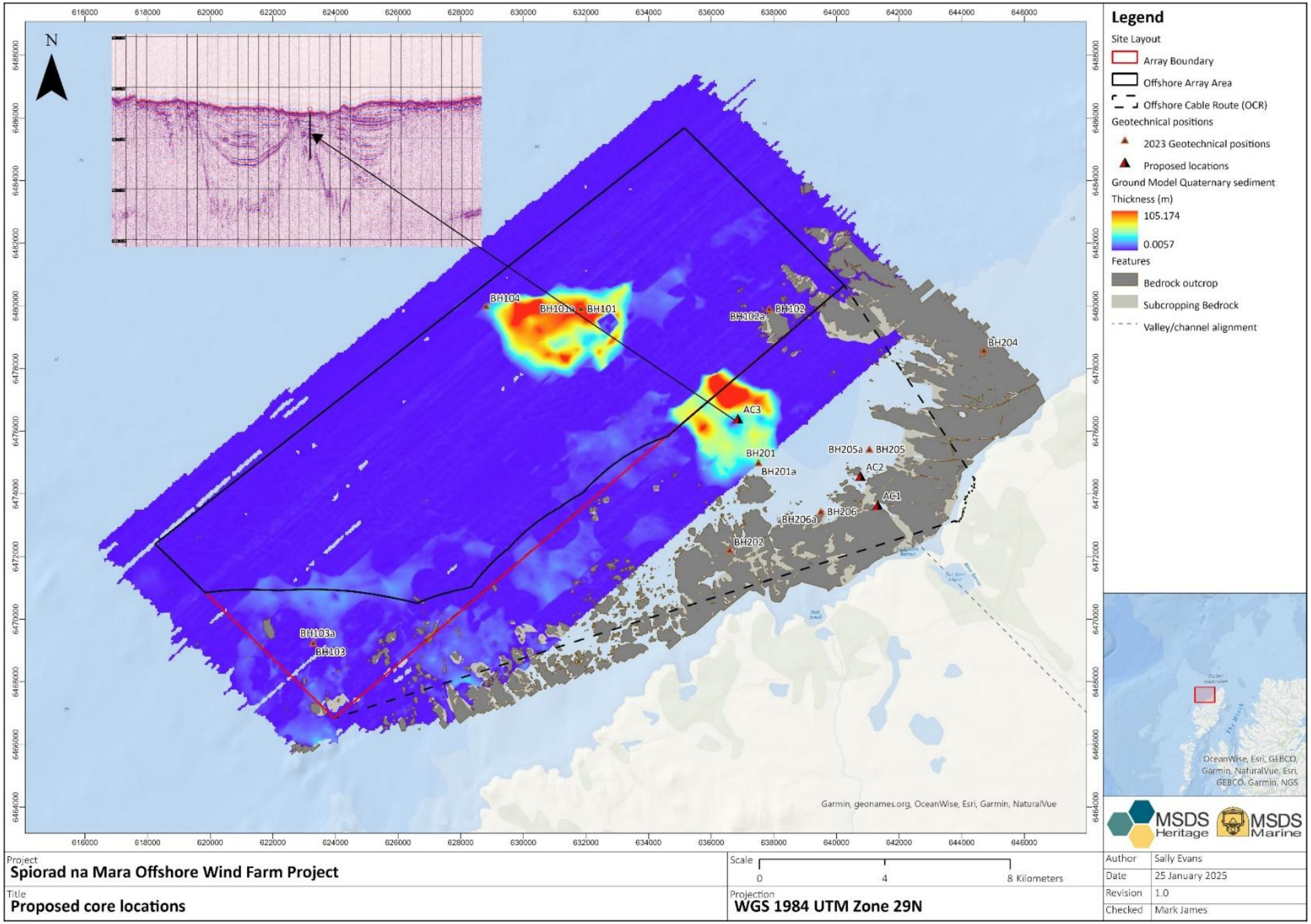

Plate 10-2 Proposed core locations (also showing line 15_011_UHRS0104_Final_Stack_Time)

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11 RECOMMENDATIONS FOR FUTURE WORK

11.1 ARCHAEOLOGICAL ASSESSMENT OF GEOPHYSICAL DATA

11.1.1.1 The archaeological interpretation of the geophysical data collected at the pre-application stage, to which this assessment pertains, fits within a wider framework of planned geophysical survey for the Offshore Project. The survey specification was designed for the purposes of consenting and project planning to determine the most appropriate area for development. Future surveys will likely combine an increase in resolution, and the addition of magnetometer data with tighter line spacing (as determined by the pUXO risk). With the data resolution and coverage set to increase, the confidence in interpretation and appropriateness of mitigation strategies will also increase.

11.1.1.2 It is recommended that should higher resolution geophysical and hydrographic data be collected, within areas of potential impact, it be subject to archaeological assessment. Additional data is typically acquired post-consent as part of the planned pre-construction and/or potential Unexploded Ordnance (pUXO) surveys. The assessment should be undertaken by a qualified and experienced maritime archaeologist that has a demonstrable background in both the collection and processing of geophysical data as well as the archaeological review of data.

11.1.1.3 The archaeological review of data at these stages is considered necessary, not only for the robust assessment of the historic environment and archaeological potential but also for development planning. As the planned surveys increase in coverage (i.e. narrower line spacing) and resolution but decrease in area, it is beneficial to be aware of any potential archaeological mitigation that may be required to ensure minimal re-planning.

11.1.2 SURVEY SPECIFICATION

11.1.2.1 Post-consent survey specifications will vary dependent on a number of factors including, water depth, vessel, and equipment as well as the purpose of the survey. However, some general specifications for data acquisition are provided below:

- **Sidescan Sonar:** data should be high frequency (at least 400-600 kHz), collected with a minimum of 200% coverage and the towfish should be flown at an optimal altitude (typically c. 10% of range). The towfish should be positioned with a correctly calibrated USBL system and layback recorded as a backup. The data should be of a quality and resolution to identify seabed anomalies >0.3 m;
- **Sub-bottom Profiler:** data should be collected at a frequency and power appropriate to the seabed type and the required penetration, vertical resolution should be <0.3 m

where possible and the data should be heave corrected. Sub-bottom data are only collected below the sensor; therefore, data should be collected on all magnetometer lines as these are generally the tightest spacing;

- **Multibeam Echo Sounder:** for archaeological interpretation multibeam data are used for general seabed characterisation and quality control for the positioning of anomalies identified in the sidescan data. Data should be high resolution (typically 300-450 kHz) and acquired within IHO Special Order specifications, this includes full coverage data and a requirement to detect features >1.0 m on the seabed;
- **Magnetometer:** the method for magnetometer surveys will vary between multiple close survey lines or multiple magnetometers in an array and wider survey lines. Magnetometer surveys for UXO identification should aim for full coverage with a sensor spacing not exceeding 10.0 m. The towfish should be flown between 2.0 m and 4.0 m above seabed and positioned with a correctly calibrated USBL system and layback recorded as a backup.

11.2 PALAEOLANDSCAPE

11.2.1.1 Following the collection of additional geotechnical samples, both those targeted for archaeological purposes, and those collected as part of the ongoing geotechnical campaign, a program of Staged geoarchaeological assessment and analysis is undertaken consisting of the following stages:

- Stage 1: Geoarchaeological review of core logs;
- Stage 2: Geoarchaeological recording;
- Stage 3: Geoarchaeological assessment;
- Stage 4: Geoarchaeological analysis;
- Stage 5: Final reporting and publication;
- Protocol for Archaeological Discoveries (PAD).

11.2.1.2 A suitable protocol for archaeological discoveries is a key element of the mitigation procedures, particularly for anomalies identified as low archaeological potential, including small magnetic anomalies. A suitable protocol should also be implemented during any works that may visually inspect the seabed or recover material to deck.

11.2.1.3 The protocol could take the form of the Crown Estates *Protocol for Archaeological Discoveries: Offshore Renewables Projects* (The Crown Estate, 2014) or a project specific protocol that considers the individual requirements of the Offshore Project. The protocol should be agreed with the curator and the regulator prior to any impact on the seabed.

11.3 GROUND TRUTHING

11.3.1.1 Should archaeological exclusion zones impact on the proposed development works it is recommended that a program of ground truthing is undertaken to establish the identity of the anomalies so that further archaeological assessment can be undertaken, and interpretations revised as appropriate.

12 GLOSSARY OF TERMS AND ABBREVIATIONS

12.1.1.1 A list of key terms and acronyms used in this annex are provided in **Table 12-1** and **Table 12-2.**

Table 12-1 Acronyms and Abbreviations

Term	**Definition**
AAP	Areas of Archaeological Potential
AC	Archaeological Core
AEZ	Archaeological Exclusion Zone
BGS	British Geological Survey
BP	Before Present
CES	Crown Estate Scotland
CM	Central Meridian Zone 29
EIAR	Environmental Impact Assessment Report
FE	False Easting
FN	False Northing
GIA	Glacial Isostatic Adjustment
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
HER	Historic Environment Record
HF	High Frequency
KIS-ORCA	Kingfisher Information Service – Offshore Renewable & Cable Awareness
LF	Low Frequency
LGM	Last Glacial Maximum
MBES	Multibeam Bathymetry
MD-LOT	Marine Directorate – Licensing Operations Team
MHWS	Mean High Water Springs
MIS	Marine Isotope Stages
MRU	Motion Reference Unit
MSL	Mean Sea Level
NLO	Named Locations
NSTA	North Sea Transition Authority
nT	nanoTesla
OCAS	Offshore Cable Area of Search
OD	Ordnance Datum
ORR	Offshore Regional Report
OWF	Offshore Wind Farm
PAD	Protocol for Archaeological Discoveries
ROV	Remotely Operated Vehicle

Term	Definition
RSL	Relative Sea Level
SBP	Sub-bottom Profiler
SLIP	Sea Level Index Point
SSS	Sidescan Sonar
TAEZ	Temporary Archaeological Exclusion Zones
TVG	Transverse Gradiometer
UHRS	Ultra-High Resolution Seismics
UKCS	United Kingdom Continental Shelf
UKHO	United Kingdom Hydrographic Office
USBL	Ultra Short Baseline
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance
VORF	Vertical Offshore Reference

Table 12-2 Glossary

Term	Meaning
the Applicant	Spiorad na Mara Limited (the Project owner).
Array Area	The offshore area within which the offshore wind turbine generators (WTGs), associated foundations, Offshore Cables, and Offshore Substation Platform (OSP) (if required), will be located. This area encompasses the Turbine Area that will contain all above water surface infrastructure (WTGs / OSP) and an additional area within which further below water infrastructure (foundations and cables) may also be located.
Environmental Impact Assessment Report (EIAR)	The Environmental Impact Assessment Report (EIAR) prepared to assess the likely significant effects of the Project on the environment.
Impact	Change that is caused by an action; for example, foundation construction (action) during construction which results in habitat loss (impact).
Landfall	This consists of works from offshore Horizontal Directional Drill (HDD) exit pits (located below MLWS) to onshore at the Transition Joint Bays (TJB) (located above MHWS). The infrastructure and installation methods associated with the Landfall involves both onshore and offshore components.
Offshore Cable Area of Search (OCAS)	The area within which the offshore electrical and communication cables between the Array Area and Landfall up to Mean High Water Springs (MHWS) will be located.
Offshore Project Boundary	The ‘red line boundary’ encompassing the Offshore Project.
Project	The Spiorad na Mara offshore wind farm development. This term describes the whole development, including all offshore and onshore components.
Study Areas	Study Areas are determined for each technical discipline and are described within each technical chapter.
Turbine Area	A reduced area within the Array Area where above water surface infrastructure would be located i.e. wind turbine generators (WTG) and Offshore Substation Platform (OSP) (if required). This area has been developed and refined through stakeholder engagement and environmental assessment.

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ANNEX 15.1.2.A – ANOMALIES OF ARCHAEOLOGICAL POTENTIAL

Name	Potential	Description	Mag (nT)	Length (m)	Width (m)	Height (m)	AEZ (m)	AEZ Type	WGS84 UTM Zone 29 N	
									X	Y
SP24_001	Low	Likely geological		6.3	1.0	0.8			639026.6	6476964.4
SP24_002	Low	Potential debris		6.5	1.3	0.9			641892.3	6477178.4
SP24_003	Low	Likely geological		9.7	1.8	1.3			641398.0	6474411.1
SP24_004	Low	Potential debris		6.5	3.3	2			638125.4	6471778.2
SP24_005	Low	Likely geological		8.1	8.0	1.8			637119.8	6471145.5
SP24_006	Low	Likely geological		4.8	1.0	1.2			639184.6	6473230.6
SP24_007	Low	Likely geological		11.7	4.0	1.2			642835.0	6476352.9
SP24_008	Low	Potential debris		3.2	1.2	1.6			638029.4	6473290.9
SP24_009	Low	Potential debris		3.3	0.7	1			638087.4	6474402.9
SP24_010	Low	Likely geological		2.4	3.7	1.3			640797.6	6477027.1
SP24_011	Low	Likely geological		49.4	25.9	0.7			621917.6	6475661.1
SP24_012	Low	Likely geological		2.5	1.5	0.3			624282.1	6476415.0
SP24_013	Low	Likely geological		3.3	3.9	2.5			622682.8	6473763.4
SP24_015	Low	Chain cable or rope		3.1	3.3	0.2			624208.9	6473773.2
SP24_016	Low	Potential debris		6.6	0.6	0.5			621654.5	6470794.8
SP24_017	Low	Likely geological		6.3	3.4	2.5			626453.2	6474719.0
SP24_018	Low	Likely geological		10.0	2.8	1.4			624415.4	6473101.9
SP24_019	Low	Mound		28.8	7.7	0.2			637920.4	6482883.9
SP24_020	Medium	Potential debris		6.8	3.3	1.2	35	Radius	635544.3	6481415.6
SP24_021	Low	Potential debris		4.5	3.3	0.6			636124.4	6481361.2

Name	Potential	Description	Mag (nT)	Length (m)	Width (m)	Height (m)	AEZ (m)	AEZ Type	WGS84 UTM Zone 29 N	
									X	Y
SP24_022	Low	Potential debris		0	2.7	1.4			639416.0	6483156.4
SP24_023	Low	Seabed disturbance		18.3	8.4	0.5			623737.9	6467905.1
SP24_024	Medium	Mound		36.4	16.8	2.8	25	Extents	623095.7	6467426.9
SP24_025	Medium	Potential debris		11.2	6.2	0.8	35	Radius	634299.7	6472656.0
SP24_026	Medium	Mound		10.3	4.6	2.4	35	Radius	628322.9	6474615.5